The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

Vol. IX PITTSBURGH, PA., DECEMBER, 1921 No. 12

American Iron and Steel Institute Meeting

Gary and Schwab Laud Aims of Arms Hope—Judge Gary Predicts Prosperity—Several Valuable Technical Papers Also Presented

THE twentieth general meeting of the American Iron and Steel Institute was held at the Commodore Hotel, New York, on November 18th. There were three sessions. The forenoon and afternoon sessions being devoted to the address of Judge Gary and the reading of a number of technical papers. In the evening the banquet was held as usual. The feature of the banquet being an address by Marshall Foch. The technical program presented at this meeting was interesting and consisted of the following papers.

Papers.

"Steel Lumber," Thomas J. Foster, chairman National Bridge Works, Long Island City.

"Welding," S. W. Miller, president American Welding Society.

"The Relations of the Iron and Steel Industries to the Chemical Industry," J. M. Camp, director Bureau of Technical Instruction, Carnegie Steel Company, Pittsburgh, Pa.

"Refractories in the Steel Plant," W. A. Hull, Bureau of Standards, Washington, D. C.

"Direct Process for Steel Manufacture," A. E. Bourcoud, metallurgist, 200 Fifth Avenue, New York City.

"Improvements in Port Construction in Open Hearth Furnaces," J. W. Kagarise, Edgar Thomson Open Hearth Department, Carnegie Steel Company, Braddock, Pa.

Abstracts of the papers which were read are contained in this issue of "The Blast Furnace and Steel Plant."

Judge Gary in his address urged that the Washington Conference go beyond an agreement for the limitation of armament and enter into a final treaty which would prevent future wars. He advocated an international understanding after the discussion of disputes between Nations before resorting to arms.

The 1,500 members cheered when the steel leader predicted success for the conference, not only per se, but in reducing the burden of taxation and causing a return to normal living conditions. Even a 50 per cent reduction in expenditures for military purposes, he said, would be a "prodigious" saving. He doubted whether there would be any decrease in the production of steel because of the limitation of armament. If any, it would be small. On the other hand, he asserted, world peace would "mark an epoch of the greatest business prosperity, as well as the largest measure of happiness, that the world has ever witnessed."

Judge Gary said that he was very "hopeful" about business and industry. Things have been growing better for the past six months and the volume of business in the steel industry has more than doubled in the last days. All in all, he expects "a return to large prosperity in the comparatively near future."

But he said that certain factors are holding back a return to normal—chief of them, taxation. He warned that any politician or party that stands for the present tax rates or opposes substantial reductions may expect defeat at the next election.

Favors Sales Tax as Fair.

"Our government is called upon as never before," he said, "to reduce expenses and expenditures and to modify and clarify taxation. The burdens are greater than we can long endure."

He favored the sales tax as fairest and cheapest to administer.

Among the other obstacles in the way of prosperity he discussed the high costs of living, profiteering by middlemen in food, clothing and shelter, high costs of production and transportation, high prices of materials and high wages.

Lauds Marshal Foch.

At the institute dinner tonight to Marshal Foch, Judge Gary hailed the noted guest as the deliverer of mankind.

"God grant that the conference at Washington will finally bring about conditions which will establish and maintain continuously and permanently peace between all nations," Mr. Gary said, "And that the guest of honor here this evening may have the pleasure of exercising a strong influence in this dinner. The men of affairs here assembled, appreciate from experience what it means to a large enterprise to have perfect cooperation of forces and perfect system in management, and they know how easy and simple to control it seems to outsiders, especially those of little practical knowledge, if the business is successful and moves without internal fiction."

Steel Men for Peace, Schwab Says.

Emphatic assurance that the iron and steel manufacturers of the United States are solidly aligned with delegates to the Arms Conference in their efforts to end wars, was given by Charles M. Schwab in an address at the dinner.

After paying high tribute to the Marshal and telling him he had been "grappled to our souls with hoops of steel," Mr. Schwab said:

I would like to take advantage of this occasion to say something which has long been upon my heart, and which at this significant moment it is clearly my duty to say. It was stated at some of the sessions of the recent League of Nations meeting in Geneva, it has often been carlessly suggested in the press, that the flame of war is in great measure kept alive by those interested in the private building of naval ships and the manufacture of munitions of war.

Thrilled by Hughes' Speech.

I can, of course, speak only for myself, but I believe I know and express the sentiments of others placed in similar positions to mine when I say this:

I am at the head of the largest war materials manufacturing works in the world. The shipyards of my company build more naval ships than are built in any other yard under one management in the United States. But I have been thrilled beyond expression, as has every good American, by the brilliant and statesmanlike scheme laid before the conference at Washington by Secretary Hughes. The carrying out of that plan may involve great monetary loss in some quarters, but such a thing as financial loss can be of no consideration when compared to the inestimable boon to mankind which would be involved in the realization of that magnificent plan.

Mr. Schwab declared that should the statesmen now assembled in Washington make it possible to bring about disarmament and permanent peace, gladly would he see "the war-making machinery of the Bethlehem Steel Corporation sunk to the bottom of the ocean." Nothing could contribute more to the permanent prosperity and happiness of the world, he added, than the conclusion of agreements among the nations of the world which would eliminate the curse of war.

"So," he said, "let us say to the men gathered at Washington, let it go out from this gathering of men of the steel and iron industry, that we are solidly behind every effort they can make which will hasten the coming of the time when war shall be no more.

Will Accept Loss Willingly.

"If disarmament inflicts a money loss upon us, the American iron and steel industry will accept it willingly and gladly. We will do so not in a spirit of mere idealism and self-sacrifice, but in a belief that the greatest permanent, material prosperity would be brought about by the concentration of the energies of mankind upon constructive activities; upon means for well-being and not for the destruction of civilization."

Improvements In Port Construction In Open Hearth Steel Furnaces

New Port Construction Which Has Increased the Efficiency of the Open Hearth—The McCune and the Engler Furnace Construction Thoroughly Described

By JOHN W. KAGARISE
Superintendent, Open Hearth Department
Edgar Thomson Works, Carnegie Steel Company, Braddock, Pa.

THE proper operation of an open-hearth furnace is nowhere more dependent upon good design than in the ports, and especially is this true with furnaces using producer gas as fuel. By far the larger proportion of furnace trouble originates in the ports, and even when perfectly designed as to size, arrangement and alignment, it is a difficult matter to keep them so.

In the pioneer days of the open-hearth, producer gas was the chief fuel used, and it was the practice of furnace builders to follow a rule of thumb formula for the construction of the port ends with the inevitable result that very little progress was made toward the solution of this most important problem.

Both ends of the furnace, alternately, are subjected every few minutes to the outgoing rush of intensely hot gases, laden with particles of iron oxide, lime, slag, etc., at a comparatively high velocity, due to the area of the port openings being relatively small compared to that of the hearth.

The temperature required in the steel bath at tapping is 2,900 deg. to 3,000 deg. F. (1,593 deg to 1,639 deg. C.), the flame temperature required is 3,100 deg. to 3,300 deg. F., and the fusion point of the silica brick, of which the ports are built, is from 3,300 deg. to 3,400 deg. F. This is a very narrow range with which to work at such high temperatures, and the action of the waste gas passing out of the furnace cuts back the ports very rapidly. There are numerous instances where furnaces have had to be shut down for repairs after making comparatively few heats. Many were the attempts made to remedy this fault and schemes beyond number have been tried to lengthen the life of the furnace.

Port Design of Early Furnaces.

The first furnace in America to make open-hearth steel as a commercial success was a five-ton furnace using producer gas fuel, designed by the late S. T. Wellman and built by the Bay State Iron Works of South Boston, Mass., in 1869. The builders made no attempt to direct the flow of the gas by the lines of the port, but depended on the depressed roof over the furnace to force down the flame into contact with the bath. The roof burned away very rapidly, the heat transfer to the bath was poor, and the life of the furnace was short.

From this time forward there were many changes in the port construction, and gradually the ports came to be built with both the gas and air openings inclined downward toward the hearth, the air being inclined to a greater degree than the gas. This construction caused the air to flow down sharply on top of the gas, kept the flame in close contact with the bath and also tended to protect the roof.

While these furnaces were a big improvement, still their life was short, and to overcome the short runs the gas arch was built longer, or nearer to the combustion chamber, to give more brickwork to wear away. This type of furnace worked slowly at first; as the long port caused the hottest part of the flame to be carried well out over the bath, the incoming end worked coldly and the gas was not fully burned before it passed out of the furnace. As the blocks and arches wore away, shortening the port and increasing the length of the combustion chamber, the furnace gained in speed and became a good working furnace. When the furnace run had lengthened and the port had burned very short, the flame was not directed properly and traveled close to the roof, soon putting the furnace out for repairs.

To prolong the life of the furnace, sand ports were often put in by placing a pipe in the port and ramming silica sand, mixed with lime or molasses, over it, to conform to the desired lines. The furnace was then heated up slowly and the pipe burned out. By the time the pipe was burned out, the sand was set, and if it did not crumble, the furnace generally made fair time on the heats. However, the life of a sand port was very irregular, a constant source of worry, and very often the cause of break-outs through the end of the hearth and serious damage to the furnace.

At several plants, the furnaces were so designed that a removable port was used. This removable port was built in a rigid framework which held all the brickwork above the charging floor level to the end of the furnace proper. A spare port was always ready and, when necessary, a burned-out port was removed and a new one installed. This type of port is practically out of existence and nearly all producer gas furnaces today use a port with a single gas opening, which is built as an integral part of the furnace.

There is no doubt that, if a properly designed brick port could be maintained, the uncooled brick port makes the most efficiently working furnace.

Water-Cooled Ports.

The result of these experiences naturally led to experiments with water-cooling devices to protect the brickwork at its vulnerable parts. Water-cooling had been in successful use at the blast furnaces for years, and naturally some of the earliest port cooling was tried with bronze blast furnace cooling plates buried in the brickwork. The effect of this cooling was an improvement in the life of the furnace while the plates lasted, but generally the life of the plates was short; and they were a complete loss, as they could not be removed when they started leaking and the water supply had to be shut off.

This led to water-cooling with steel pipes of various sizes, each pipe connected to its own water supply, so that when a pipe started leaking and the water was shut off, the loss was not great. Some of the early types of pipe cooling devices which have been developed and are now in successful use are the small pipe ports developed and at present in use at the South Chicago Works of the Illinois Steel Company, the so-called Parks port developed at the Duquesne Steel Works of the Carnegie Steel Company, and now in service at that plant and at the Edgar Thomson Works of the same company, and the 8-inch flattened pipe block and arch cooler developed at the Gary Works of the Illinois Steel Company and Farrel Works of the Carnegie Steel Company, and now in service at the Farrell Works, the Ohio Works and at the Edgar Thomson Works in connection with the Parks port.

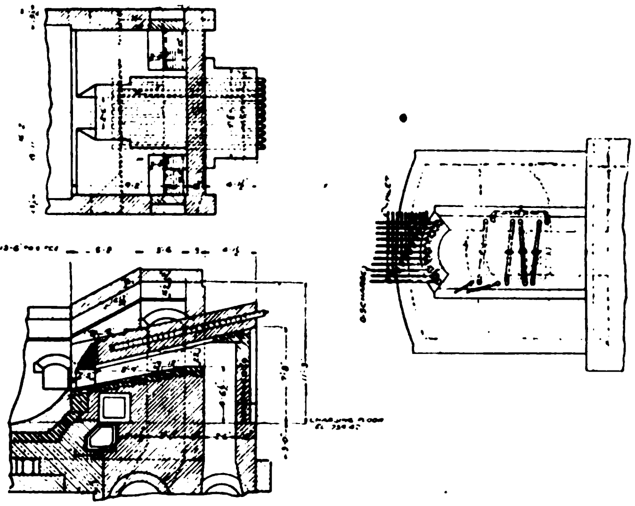

Fig. 1—Park water cooled port used at Duquesne and Edgar Thomson Works of the Carnegie Steel Company.

South Chicago Water-Cooled Ports.

About the earliest record we have of water-cooling devices is that of the small pipe coolers used at the South Chicago Works of the Illinois Steel Company. The water used at that plant is taken from the lake and is always clean and leaves very little deposit in the coolers. The first water-cooled ports put into operation were 1-inch pipes and were installed in No. 1 Open-Hearth Department, when they changed from natural to producer gas in 1903. The pipes were straight, were located at the mouth of the port and only cooled the front of the port arch. The pipes were later bent to cool the two sides and top of the gas port mouth.

Still later the pipes were brought through the port blocks at different elevations, one pipe behind the other, to protect the block, and all bent to cool the port on the two sides and top. This latter type port, with a few modifications, has been in use for the past eight years, and gives a life of from 300 to 400 heats.

Parks Port.

In the fall of 1909, water-cooling devices were tried in the ports of the open-hearth furnaces using producer gas at the Duquesne Steel Works. The original dry port arch of their furnaces was formed of 13-inch silica brick. For the water-cooled port, an arch of 9-inch brick was laid the length of the gas port; four pipes, four inches in diameter, with their furnace ends welded shut, were laid on top of the arch and the water was fed into them through a 1-in pipe, close to the welded end; the water, passing out of the cooler through a fitting on the outer end, was used for cooling the doors and frames. These pipes were spaced equally on the 9-inch arch and the space between filled in with brickwork. This scheme worked very well and good runs were made on the furnaces in comparison with dry ports. At times the gas would leak up through the arch between the pipes, but patching was easily accomplished. A mixture of magnesite and chrome ore was used in patching, and one port was put in with this mixture with very good results, but it was too costly. The experiences with the four pipes in the ports, and the leaking of the gas through the arch between the pipes, led to the adoption of the present Parks port. This port, as shown in Fig. 1 is constructed by laying the four-inch pipes as close together as possible, leaving just enough room to remove a leaking cooler and replace it with a new one. The pipes, of which it takes eleven to cover the arch, are covered with a 4½-inch arch of brickwork.

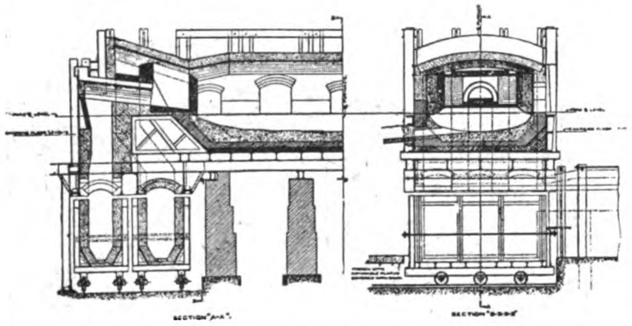

Fig. 2—Latest design of the Blair water cooled port.

The condition of the cooling water at the Duquesne Works and Edgar Thomson Works is very bad at times, as considerable foreign matter is pumped into the lines and a number of cooling pipes are lost. With this arrangement the cooler can be changed very quickly, and the life of the port averages from 300 to 400 heats.

In addition to the ports here described, there are several water-cooled ports on the market, the two best known being the Knox port and the Blair port.

Knox Port.

In the year 1906, Mr. L. L. Knox became interested in the subject of water-cooling and for several years devoted his entire time to study and experiment with the object in view of designing a port that would outlive the rest of the furnace.

Among his early attempts along this line was the introduction of a hollow copper casting over the top of the gas port, through which a constant stream of water was kept in circulation. While this served to keep the gas and air separate until they reached the combustion chamber, it did not prevent the sides of the gas port from becoming distorted and burning away. Side coolers were then added, which extended down to the floor of the port opening.

This design met with a fair amount of success, but the first cost of the copper castings, coupled with the expense of repairs, made it almost prohibitive.

Mr. Knox then turned his attention entirely to welded steel plate construction. From the very first it was found that steel plates have all the qualities of strength, ductility and conductivity that make them especially applicable for the purpose, and that they could stand contact with furnace slags and oxides without injury. Port coolers manufactured from rolled steel plates and designed practically similar to those of the copper castings were made for several years with varying success.

During the year 1911 the cross port cooler was designed along somewhat different lines. The cooler was carried across the port next the furnace and extended through the front and back walls. This gave access to the water connections and made it an easy matter to clean out the sediment that always deposits itself at the low places. A brick-lined opening was provided through the center of the cooler, which opening forms the mouth of the gas port.

Many improvements have been added from time to time, the most important of which was the lowering of the wings on either side of the central opening, or gas port. This allows the floor of the air port to be built to a very much lower level, thus providing a means of more completely surrounding the incoming gas with the hot air from the furnace checkers.

Blair Ports.

The port as first designed consisted of a flat, water-cooled, welded steel hood, and when installed in the basic furnace, the whole end blocks, ports and uptakes were built of ground magnesite. The gas port arch was replaced by the hood, which rested on each side of the port on the magnesite block, covering the gas port completely, and having an insulation of ground magnesite on its upper side, so that all seams in the hood were protected from contact with the flame. The hood was carried forward to the point at which the greatest efficiency and fuel economy were secured. If installed in an acid furnace, the end blocks could be built of silica sand or brick, the water-cooled hood replacing the brick arch.

The first installation was made at the Lackawanna Steel Company's Works in Buffalo, N. Y., in July, 1907, and was so successful that it was followed by other installations, until in 1913 this type of port was used in the building of the 250-ton tilting furnaces and up to January, 1919, six years, the original ports were still in use.

While this type of port was successful for a number of years, it was found that the life of the port was limited by the destruction of the magnesite side walls, so the later form of port, as shown in Fig. 2, with the semi-circular hood cooler forming the complete gas arch and side walls was adopted, and to a great extent decreased the use of magnesite in the port ends, thus greatly reducing the cost of construction.

The types of water-cooled ports just described are successful, and there are others in service which are doing good work, but it is impossible to describe them all; and it is a fact that no manufacturer in this country would consider building a modern open-hearth furnace without installing water-cooling in the ports, the type of the port to be selected to be determined by the engineers, governed by their fuel, water and local conditions, keeping in mind the fact that the best water-cooling is that which protects the vulnerable parts of the ports, and yet exposes the minimum amount of surface to the hot gases.

Ports for Burning Liquid Fuel and Powdered Coal.

The burning of oil, tar and powdered coal as fuel for open-hearth furnaces has been in practice in this country for a number of years. Their efficient burning depends more on the burner used, and its ability to properly atomize the fuel and direct the flame, than on the port construction. Water-cooled burners, which obviate the necessity of removal after each reversal, have been installed in furnaces with ports built for producer gas and natural gas, with modifications of both, and with ports built especially for these fuels, but the fuel consumption and furnace life are practically the same.

Developments in Methods of Burning Fuel.

The use of by-product coke oven gas as an open-hearth fuel introduced new difficulties in flame control and efficient combustion of the gas. As a result, in the last few years, many experiments have been made in changing the lines of the furnace ports * to more intimately mix the gas and air, thereby getting quicker combustion, or by the introduction of dampers in the ports or uptakes, to restrict the incoming air to a small area and thereby give it a high velocity, with the idea in view of burning the fuel with more efficiency. Such ports are primarily intended to be used with furnaces burning by-product gas and producer gas, but may be used for burning other fuels with some degree of success. Such relations were illustrated in principle, in 1912, by Mr. C. A. McCollum of the Homestead Works, and stated by him, in a report covering the efficiency of a furnace, as necessary with forced draft and desirable under all conditions.

Among the many experiments that have been tried and seem to be standing the test are the McKune System, the Venturi Line Furnace and the combination of the McKune System and the Venturi Line Furnace at the South Chicago Works, and the Egler Furnace in use at the Brier Hill Steel Company, Youngstown, Ohio.

McKune System.

The McKune System, originally installed in the Open-Hearth Department of the Steel Company of Canada, Hamilton, Ontario, consists of a volume air blower, which is attached to the reversing valves and furnished air for the furnace at a pressure of six ounces per equare inch.

The air is introduced through the checker chambers into a well and from there through a central port similar to that of a gas producer furnace. This further resembles the modern gas producer furnace in having two outside uptakes and one central uptake leading from the slag pocket, the two outside uptakes uniting in one common opening above the central port. The two outside uptakes, at either end of the furnace, are equipped with water-cooled dampers. These dampers are placed about four feet above the charging floor level, and are operated by a hydraulic manpulating system.

By-product coke oven gas is used as fuel and is introduced in either side of the central port at right angles to the line of the port. The dampers are so arranged as to close the outside uptakes on the incoming end and open them on the outgoing end. Therefore, the air on the incoming end must all rush through the central port under blower pressure, picking up the gas in its travel, which burns with an intensely hot and complete combustion within the first ten feet of the hearth; then there is a slowing down of the products of combustion into the greater volume of the outgoing end, since the outside uptakes on that end are open.

Venturi Line Furnaces.

The Venturi Line Furnaces, as shown in Fig. 3, so called because of the resemblance of the port lines to the lines of the Venturi Meter, were developed at the South Chicago Works, and in a measure along the principles involved in the McKune Type of furnace. They were designed with the idea of obtaining better combustion and flame control with their producer gas fuel. To accomplish this purpose the port area at the entrance of the furnace was greatly decreased by lowering the roof knuckles and moving the monkey or wing walls in, and in this manner a restricted opening for a short distance was obtained, with an easy approach on either side of it. In addition, the mouth of the gas port was placed back about three feet from the point of greatest restriction or neck, thus providing a chamber in which the gas and air could be thoroughly mixed before entering the furnace proper. No fan blowers are used on these furnaces, but all are equipped with waste heat boilers and induced fan draft. This construction has proved successful and has been installed in all their furnaces.

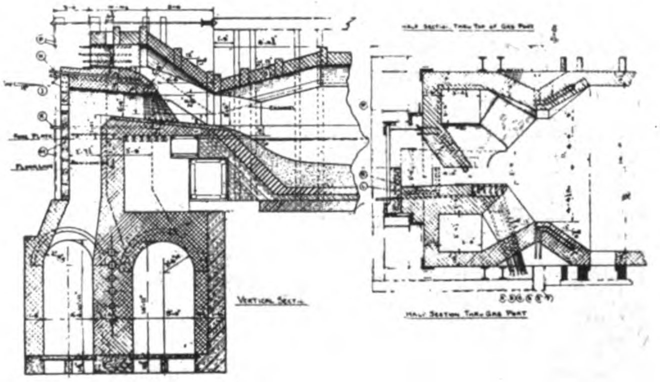

Fig. 3—Venturi line furnace, South Chicago Works, Illinois Steel Company.

A further development of furnace ports is being worked out at this plant by combining the McKune System with the Venturi Line Furnace. Instead of drawing in the monkey or wing walls and thus restricting the outgoing end, as well as the incoming end, a system of water-cooled dampers is installed. These dampers enter the port, one on either side of the gas port, through the roof at the knuckle, or point required for the greatest restriction, thereby taking the place of the wing walls. The dampers are operated so that the two on the incoming end are in the furnace, while the two on the outgoing end are out of the furnace, thus restricting the flow of the incoming gas and air through a neck with an opening of 13 square feet, and permitting the waste gas to escape through an opening of 31 square feet. The furnace is equipped with a fan which forces in the air used for

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*See F. L. Toy on "The Basic Open-Hearth Process," American Iron and Steel Institute Year Book, 1920, page 345.

combustion as well as being equipped with a waste heat boiler fan which draws out the waste gases. The furnace has been doing wonderful work and has been attracting attention from all sides.

During the month of August, the furnace, which produced an average heat last year of 72.6 tons, operating continuously, made 105 heats of 76.4 tons each, or a production of 8,020 tons. The average time of the heats was 7 hours and 5 minutes, tap to tap, including all delays. It was operated on a charge of 53.2 per cent hot metal, 41.2 per cent scrap and 5.6 per cent metal from the ore. The consumption per gross ton of ingots produced was 400 pounds of coal from the Lynch mine located in eastern Kentucky, of 13,200 Btu value. As this furnace was an experimental one, it was taken off early in September and some changes made in the water-cooled frames of the dampers, as it was felt that there was too much water-cooling exposed to the pre-heated incoming air, and that it tended to unnecessarily cool the air.

The furnace was again put in operation and another run of a month was made, from September 15 to and including October 15, to correspond with the number of days in the previous trial month, using the same charge, and with the same operating conditions. On this run the furnace made 106 heats of 85.5 tons each for a total production of 9,059 tons. The time of heats was 7 hours, 1 minute, tap to tap, and the coal per ton was 348 pounds.

The furnace received the greatest care and attention, and everything possible was done to speed it up, with the idea of finding out what could be done. The steel it produced was made on the regular orders and ranged from .08 to .45 carbon. It is not to be expected that this furnace will do as well working under normal conditions, without special attention, but it should at least show results 70 to 75 per cent as good as those given.

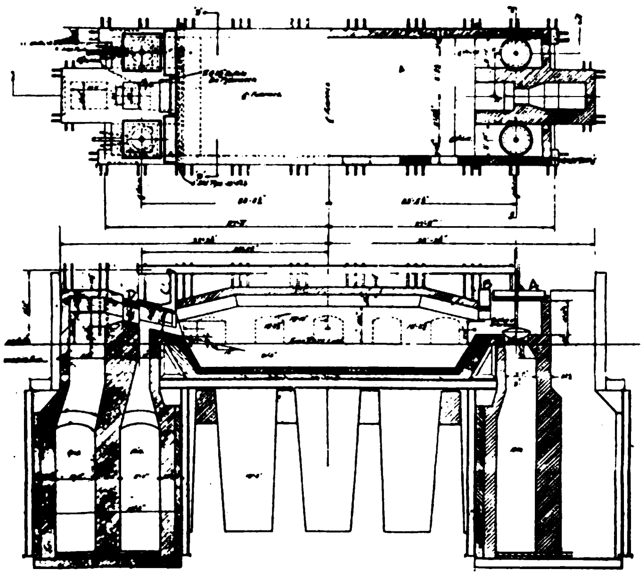

Fig. 4—Egler furnace, The Brier Hill Steel Company, Youngstown, Ohio.

Egler Furnace.

The Egler Furnace, as shown in Fig. 4, was conceived with the idea of making the flame enter the combustion chamber with a blow torch effect. Two of these furnaces, one using producer gas and one natural gas, have been installed in the works of the Brier Hill Steel Company, Youngstown, Ohio.

In order to accomplish the results desired, it was necessary that all the gas and air needed for combustion should pass through a port designed as a combined fuel and air port. In the producer gas furnace the air is forced into the port by fan pressure, and the gas is delivered at the regular producer pressure. The gas comes into the combined gas and air port through the uptake farthest from the furnace and is turned and directed downward toward the hearth in the usual way. At a certain point in its travel through the port, the gas meets a stream of air fed vertically upward and across the stream of gas. The port is so constructed that the air flows around the gas, above and below it. As soon as the gas and air meet, combustion immediately starts, and while the temperature within the port itself is not unduly high, combustion is complete by the time the flame has reached the middle door of the furnace. In the natural gas furnace, the air, the combined gas and air port through the uptake which is used for gas on the producer gas furnace. The natural gas is admitted through pipes at a point between the air uptake and port outlet to the furnace.

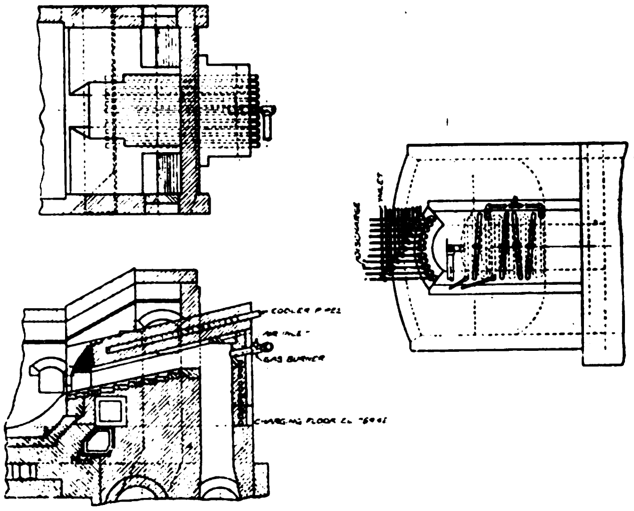

Fig. 5—Showing by-product gas burner installed in end of producer gas furnace at Duquesne, Works.

At each end of the furnace are two flues, auxiliary to the main gas and air uptakes. These flues at the upper end are fitted with water-cooled mushroom valves on water-cooled seats. On the incoming end the valves are closed and no air can enter the furnace through these flues, all air being forced to enter through the combined gas and air port. On the outgoing end the mushroom valves are open, permitting the waste gas free passage out of the furnace through all the flues.

Both of these furnaces have been operating for some time and are giving good results, 75-ton heats being made in an average of 7½ hours, with a fuel practice of approximately 400 pounds of coal per ton of steel on the producer gas furnace, and 3,700 cubic feet of gas per ton on the natural gas furnace.

Burning By-Product Gas With a Luminous Flame.

The burning of by-product gas in an open-hearth furnace has always given more or less trouble, because of the difficulty of keeping the flame down on the bath; and from the fact that it burns with a non-luminous flame, it was difficult for the furnaceman to know what he was doing. It has been the general practice to use tar in amounts dictated by experience for the purpose of giving luminosity to the flame. The usual procedure was to blow a jet of tar, atomized by air or steam, through the port, immediately over the incoming gas.

During the year 1918 a gas line was completed connecting the by-product coke plant of the Carnegie Steel Company, located at Clairton, Pa., with the Duquesne Steel Works, to supply the latter with coke oven gas as a substitute for natural gas. After this gas was made available, many experiments were required to effect its satisfactory substitution. The object of the experiments was to obtain, without the introduction of tar, the elementary principles of natural gas, namely, luminosity and a non-oxidizing atmosphere when necessary.

In the open-hearth practice, it was found that by the introduction of a small quantity of air in the burner, forming a primary combustion at that point, a luminous flame could be obtained in the furnace. It was also found that by varying the quantity of air introduced in the burner, full control of the flame from non-luminous to densely luminous was possible. For the secondary combustion, the required air was brought in through the ports in the regular manner.

The Duquesne Works has thirty-two producer gas fired open-hearth furnaces, each two connected to the gas producers by a single underground flue. Although the flues were burned out regularly every week end, a deposit accumulated in the underground flue, which had to be removed periodically by hand. This necessitated shutting down the two furnaces connected to the flue, which resulted in a considerable loss of tonnage.

To overcome this loss, all furnaces were equipped, as shown in Fig. 5, to burn by-product gas during the cleaning period, and all furnace crews have been required to burn this fuel, which they have done successfully and with good fuel practice.

The time of changing from one gas to the other ranges from fifteen to thirty minutes, and except for the introduction of the burner and admitting air through both the gas and air ports, when burning by-product gas, there is no change in the operation of the furnace.

At times when the gas supply was plentiful, the furnaces have been operated with it for varying periods, one furnace making a run of 55 heats, producing 3,044 tons of steel, with a fuel practice of 9,574 cubic feet per ton.

In conclusion, it may be stated that while progress has been made in the last decade in improving the design of the open-hearth furnace, the result being larger furnaces, increased life and a decreased fuel consumption, yet the field for further improvement is large and every open-hearth superintendent and engineer should be on the alert to introduce such changes in design and practice that will tend to a more efficient burning of the fuel.

Steel Lumber and Its Application

Simplified Examples of the Use of Steel Lumber—The Possibility of Steel Replacing Wood in Building Construction

By THOMAS J. FOSTER
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THE good qualities of wood as a building material, the ease with which it could be secured in all parts of our country, and the convenience of handling have made it hard to replace, especially in the building of floors and partitions. Wooden joists make light supports and are conveniently spaced for the fastening of the lath for the ceiling and for the rough flooring. If wood were fireproof and did not shrink, it would be the ideal building material, but the lack of these two qualities, coupled with the fact that it is getting scarce, must drive it out of the building material market in our thickly populated communities. The fire hazard in our cities is too great to permit the use of wood except under certain restrictions; and as the population of our cities increases, the greater will be the need for having all construction fireproof. The growing scarcity of wood and the increasing need of fireproofing will develop constructions that will make it uneconomical in our cities to build of combustible materials.

In looking for the ideal material for floors we should keep all the good qualities of the wood floor and eliminate the bad ones. In the earliest types of fireproof floors, fireproofing materials were so little known that only crude floors made of brick arches, or heavy concrete arches between iron beams, were used. The result was expensive and the necessity of having fireproof buildings brought out better designs as shown by the flat tile arch supported by steel beams. Arches finally gave way to flat slabs of concrete supported by steel or reinforced concrete beams. This construction did not give a flat ceiling except at an extra expense, and consequently many hotels and apartment houses have the beams projecting into the rooms. None of these types had the good qualities of wood construction. They required wooden forms for putting the material in place. Some of them took as much wood as was necessary to build the floor only to have it all torn out. All of them were too heavy. Economy calls for the building of a floor with no waste materials in its construction. Fig. 1 shows a comparison of the weight per square foot of various fireproof floor constructions worked out for the same loading and span.

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Steel lumber consists of light structural steel members in the form of I-beams and channels of approximately one-third the weight of the standard sections of equal depth, and primarily designed to fulfill the functions of wooden joists and studs. The manner in which I-beam sections are made from channels by riveting or spot-welding and the method of attaching metal lath are shown in Fig. 2.

The adaptability of this material soon secured it a position in the various types of fireproof construction, and today you will find these sections installed in office buildings, hotels, schools, apartments, light factories, light warehouses, theaters, garages and residences.

In the year 1901 the first small sections and in 1907 the first steel lumber joist sections were made of sheet steel. The sheets were slit and formed into channel sections on brakes. The I-sections were formed by placing two channel sections back to back and riveting them (see Fig. 2). Lengths greater than 16 ft. 8 in. were made by splicing. The first installation was made in a two-family Tuxedo Park Association. The entire frame of the building including the joists, studs and rafters was made of this material. Metal lath was attached to the studs as a base for the stucco on the exterior and for the plaster on the interior. Metal lath was also placed over the tops of the joists which formed a support and furnished reinforcing for a two-inch concrete slab. Wooden nailing strips were fastened to the steel lumber joists and embedded in the concrete as a base for the wood floors. Metal lath was attached to the bottom of the steel joists to support the plaster ceiling. This was the first time a fireproof construction was used having the good qualities of wood construction. It was built by the Taft-Howell Company of Cornwall-on-the-Hudson.

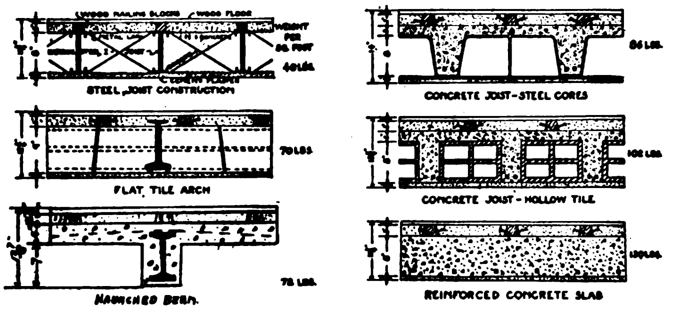

Fig. 1—Comparison of the weight per square foot of various fireproof floor constructions. Note the light weight (40 pounds) of steel lumber construction.

The present method of producing steel lumber was started in 1919. The finished strips are made from slabs in a single mill. These slabs are from 8 in. to 16 in. wide by 3½ in. thick and weigh from 300 to 700 pounds each. A specially designed hot strip mill takes these slabs down gradually to strips of .072 inches to .102 inches gauge and widths up to 17 inches. The strips are made 130 feet long, finished hot and coiled. The coils, when cold, are fed into forming mills which produce the steel lumber channel sections. I-sections are made by placing two channel sections back to back and passing them through automatic spot-welders. Two rows of welds ⅜ in. diameter are staggered along the web of the section. The ends are trimmed and the pieces cut to length by high-speed friction saws. The steel lumber is piled for convenience in handling and is then dipped in a large vat of special paint. This insures the paint getting to every portion of the steel. The painting is for protection until the steel lumber joists are installed in the building. After they are in place and the building completed, as in all buildings, conditions that cause corrosion do not exist.

In one mill producing these sections, having a capacity of 8,000 tons per month, the steel used is of standard analysis, carbon content of from .16 to .24. Phosphorus and sulphur are held under .04 and manganese under .35. This relatively high carbon content, together with the method of working the material, gives a uniformly high ultimate strength. The material from this mill will show an average ultimate strength exceeding 72,000 lbs. per square inch, compared to 60,000 lbs. per square inch for the rolled sections.

The channel sections are furnished only up to 6-inch depth and are used for studs in partitions. The joists are furnished in 4-in., 5-in., 6-in., 7-in., 8-in., 9-in., 11-in. and 12-in. depths. The flange widths are designed to secure the best working stresses in all parts of the section. The 4-in., 5-in. and 6-in. joists are 3 in. wide; the 7-in. section 3½ in. wide; the 8-in. and 9-in. sections, 4 in. wide; and the larger sections are 4½ in. wide.

While the steel lumber joists, spaced 16 in. to 24 in. center, will require a little more steel than is used ordinarily for the steel beams in some types of floors, yet the dead weight of the floor being only about 40 lbs. per sq. ft. instead of 80 lbs. or more as required in some other types of fireproof floors, requires less steel in the girders and columns, and less material in the foundations. Economy in the use of steel lumber results from the following causes:

(1) The distribution of the steel requires less of other materials, eliminating their cost and the cost of carrying them.

(2) All of the material used in steel lumber construction is a part of the permanent structure, and only enough material is used to give strength and rigidity.

(3) Less labor is used in producing the structure, as less material is put up, and there is none to come down and be carted away from the building.

(4) It requires less time for construction. This results in getting the building ready in a shorter time for business or for the collection of rents, and cuts down the interest accruing on the investment in the land.

(5) The cost of insurance and of maintenance is less in the steel lumber construction than in wood. In some cases these reductions will make the cost of the fireproof structure as cheap as the wooden structure after a period of ten years, and it will be a better and longer lived building.

The steel industry should be capable, by producing better shapes of the steel lumber type with the cheapness due to quantity production, of lessening the economic loss due to fires. The National Board of Fire Underwriters gives the losses due to fires in the United States for the five years previous to 1921 as $1,416,000,000. This figure is the adjusted fire losses with 25 per cent added for unreported fires and those occurring in uninsured properties. For the total economic loss you must add to these figures all the incidental losses, which sometimes amount to as much as the fire losses themselves.

The same authority says that "over 90 per cent of our school buildings are potential death traps." "Figures compiled by the National Board of Fire Underwriters through its Actuarial Bureau show that in 1918, the last year of completed statistics, there were on the average nearly five school fires for every day of the 365 days, or a total of 1778 fires for the year."

The fire resisting quality of a floor is of the greatest importance and in the first attempts at fireproofing a large quantity of material was looked upon as necessary. Experiments as well as actual fires have shown that it is largely the ability of the incombustible fireproofing materials to expand and contract satisfactorily which makes a good fireproofing material. From the study of the Baltimore and San Francisco fires it is shown that cement plaster on metal lath stood the fire better than the heavier materials, for instance, tile.

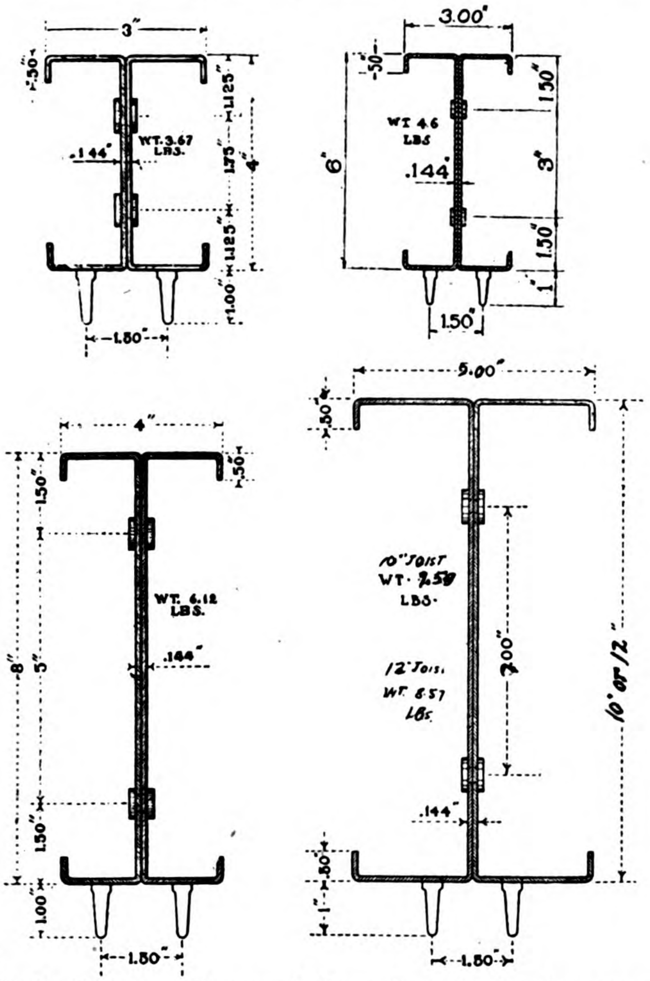

Fig. 2—I-beam sections made from channels, showing prongs punched out of flange to engage metal lath. The channels are here shown riveted.

Tests were made of steel lumber construction by the City of New York on April 14-15, 1915. A floor designed for 150 lbs. per sq. ft. live load was erected over a furnace and loaded to 150 lbs. per sq. ft. with pig iron, and a temperature of 1,700 deg. F. was kept up for four hours. A stream of water was then played on the ceiling and there was practically no damage by fire or water. The next day after the fire the floor was loaded to 600 lbs. per sq. ft. and after such loading had a deflection that was not excessive.

Floors as usually constructed are composed of a large quantity of material and subject to bad cracks, no doubt caused by uneveness of expansion and contraction. Steel lumber floors show no cracks. The steel can always be depended on to do its work properly, and the two inches of concrete on top of the steel with the embedded metal lath will prevent any uneveness of expansion and contraction. The ceiling is also protected against cracking by the metal lath and cement plaster, forming a uniform material over the entire surface.

No change has been made from the original method of installation of steel lumber floor. The steel lumber is put in as joists from 16 in. to 24 in. centers. Metal bridging is used between the joists. Metal lath is stretched over the joists and wooden nailing-strips are fastened to the joists through the metal lath. Cinder concrete or other fireproof material is filled in on top of the metal lath and between the wooden strips. For the ceiling the lath is fastened by clips to the lower flanges of the joists and cement plaster is used on the lath (see Fig. 3).

Steel lumber was not produced on a tonnage basis until 1919, and its value has been recognized, as shown by the fact that 30 million square feet of this construction has already been installed throughout the country.

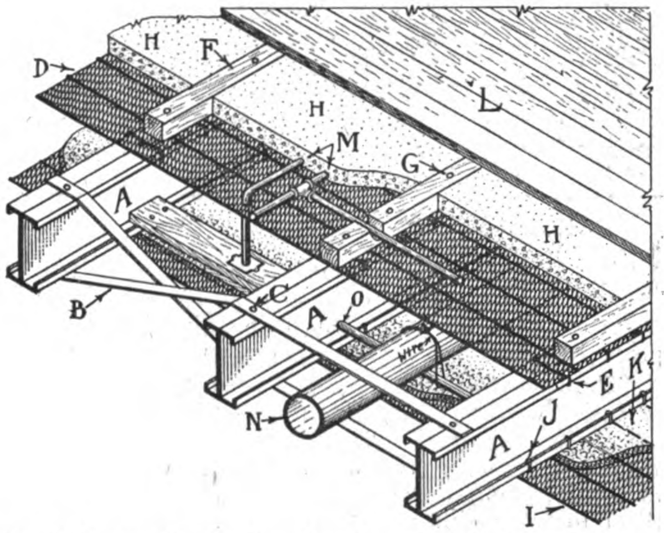

Fig. 3—Isometric drawing showing steel lumber floor construction. A—steel lumber I-joist. B—Metal cross bridging. C—6-d. nail for securing bridging to steel I-joist. D—Metal lath for top of steel I-joist. E —Spring clips for securing lath to top of steel I-joists, clips to be spaced about 8 in. centers. F—1¾x1¾ in. wood nailing strips. G—12-d nail for securing wood strips to tops of steel I-Joist, nails to be spaced 18 in. to 20 in. centers. H—Concrete fill. I—Metal lath for ceiling. J—Spring clips for securing metal lath to bottom of steel I-joist, clips to be spaced 6 in. centers. K—Plaster. L—Wood finish floor. M—Water pipes and electric conduits. N—Soil pipe. O—Small pipe resting on bottom flanges of steel I-joists to support soil pipe.

The steel lumber type of floor, as shown by the isometric drawing (see Fig. 3) is ideal. Each part is made of material whose strength is a certainty, no more material is used than is actually required, and no material is used that is not a part of the finished structure.

The steel lumber section itself is not ideal; too much of the weight is in the web. This objection is partly met in the sections showing the angles spot-welded to the web, but it has the disadvantage of being made up of five separate pieces. This floor construction is in its infancy and we expect to see some engineer solve the problem of producing an "I" section of light material that will have the right proportion of web and flange. Theoretically, this should give a section weighing not more than 70 per cent. of the present section and with a carrying capacity greater than the present section, making the theoretical section 50 per cent more efficient than at present. This is not impossible.

Residence work, including apartments, is 20 per cent of the total building of this country. The majority of this is furnished by so-called speculative builders. The houses are built to sell. No dollars will be put in on which quick returns cannot be made, but with an ideal steel joist, that can be installed as cheaply as wood, the tide will be turned and a large share of these wooden structures will be built of steel. The buildings now being erected with fireproof materials will be materially reduced in price by using the steel joist type of floor, the amount depending on various conditions, such as the use of the building, the load to be carried, and the location of the building. This will call, not only for a large quantity of joists, but the joists will require rolled beams, and they will require steel columns. Thus the entire steel industry will receive an impetus and those occupying buildings, whether for residence, for business, for church or for schools, will have the benefit of cheaper occupancy and, for all of them, an occupancy safe from fire.

Fusion Welding in Steel Plants

Fusion Welding Is Performed by Actually Melting Together the Pieces to Be Joined by the Application of a Very Local But Very Intense Heat

By S. W. MILLER
President American Welding Society

I HAVE been asked to present for your consideration a paper on the subject of fusion welding. These processes, for there are several of them that may properly be included in the term "fusion welding," are in their present applications of comparatively recent origin.

The term "welding," as used before the introduction of fusion welding methods, was well understood to apply only to wrought iron and steel and the operation was performed by bringing two or more pieces of these metals to a pasty condition by means of heat and then forcing them together either by hammering, pressing or some other mechanical means. Fusion welding, as the term implies, is performed by actually melting together the pieces to be joined by the application of a very local but very intense heat, so that only a small part of the pieces to be joined is brought to the melting point. It is not only not necessary but it is undesirable to force together the pieces when these processes are used, so that fusion welding is radically different from welding as formerly understood and applied. A further point of difference is that fusion welding is applicable to all metals. The oldest instance of fusion welding is lead burning, which has been in use for many years.

Processes of Fusion Welding.

The processes of fusion welding in use at the present time depend for their sources of heat on three reactions:

First: The burning in the presence of commercially pure oxygen of a combustible gas; acetylene is the one most frequently employed, although hydrogen, city gas and others have been successfully used.

Second: The electric current.

Third: The thermit reaction.

The first process, in its widest commercial application, makes use of acetylene as the combustible gas because it produces the highest flame temperature known, probably about 5,500 deg. F. This is by reason of its very large carbon content, 92.3 per cent.

The second process may be utilized in two principal ways: First, by striking an arc between the piece to be welded, which is attached to one terminal of the circuit, and a rod of carbon or graphite connected with the other terminal. The maintaining of the arc produces an intense heat which melts the metal; necessary additional metal can be provided to fill cavities, etc., by holding in the arc a rod which is melted into the cavity. Second, by striking an arc between the piece to be welded and an electrode of metal, which on account of the heat of the arc is melted into the piece being welded, thus filling up the cavity or joining the pieces of metal together.

The thermit reaction is based on the fact that aluminum has a much stronger affinity for oxygen than most of the other metals, so that if powdered aluminum is mixed with a metallic oxide, such as iron oxide, and the mass be brought to a high temperature at one point by means of a red hot piece of iron, for example, the aluminum will combine with the oxygen of the oxide, setting free metallic iron. The reaction is propagated automatically through the mixture with the result that aluminum oxide floats on top of the melted metal, which can be poured into a mold or otherwise utilized. In practice, the ends of the pieces to be joined are brought to a high temperature in the mold surrounding them, into which is poured the thermit metal, which fuses into the pieces to be joined, making a solid fused joint.

The oxyacetylene process, or as it is frequently called, gas welding, is applicable to more metals and more conditions than either of the other processes. It is limited in its application chiefly because it is difficult for practical reasons to use it on very large sections of steel, although it has been applied under suitable conditions and with suitable precautions to such large sections. Its

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Abstract of paper presented before American Iron & Steel Institute, New York, November 18, 1921.

cost is high in the case of large pieces compared with the other processes, because of the high cost of gases, but the tanks in which the gases are compressed and the rest of the apparatus are easily portable, making it very easy to take to the work. The electric arc processes are in some respects more difficult of application because of the necessity of protecting the operator from the effect of the ultra-violet and infra-red rays of the arc, as well as from its intense glare and heat, so that the operator must wear gloves, masks and clothing that will prevent these rays from reaching the skin. In hot weather these precautions are oppressive, particularly in the case of the carbon arc. The precautions necessary in the case of acetylene welding are not so great, as the dangerous rays referred to are present in only a small degree and proper goggles are all that is necessary to protect the eyes from the glare.

For carbon arc welding a current as high as 1,000 amperes at from 60 to 75 volts may be used, whereas a current of less than 300 amperes is of but little value. Under these conditions, some care must be taken to protect the operator against the current, and wet gloves or shoes may be more or less dangerous. With the metallic arc, a current as high as 200 amperes may be required with an arc voltage of from 18 to 20. The temperature of the positive crater of the carbon arc is about 6,300 deg. F., but, so far as I know, the temperature of a metallic arc has never been determined; it is, however, very high and much more local than that of the oxyacetylene flame. The carbon arc process is usually confined to filling cavities in steel castings, although it has been used with great success in some cases for other purposes. It is not, however, as popular as the metallic arc, although the latter is confined for most practical purposes to the uniting of steel and wrought iron. The thermit process is of particular value for the welding of large sections of steel, and has proven of inestimable worth in the repair of such parts as stern frames and rudder frames of steamships, many notable instances of which could be cited. The temperature of the melted thermit steel is probably about 5,000 deg. F. It is not possible to state any fixed limits to the application of the various fusion welding methods. Under some conditions the acetylene process would be better for the same job than the electric or the thermit, and vice versa. In many large plants acetylene and electric welding are interchangeably used and with equally good results, so that it is quite futile to make any statement as to their relative merits in this direction.

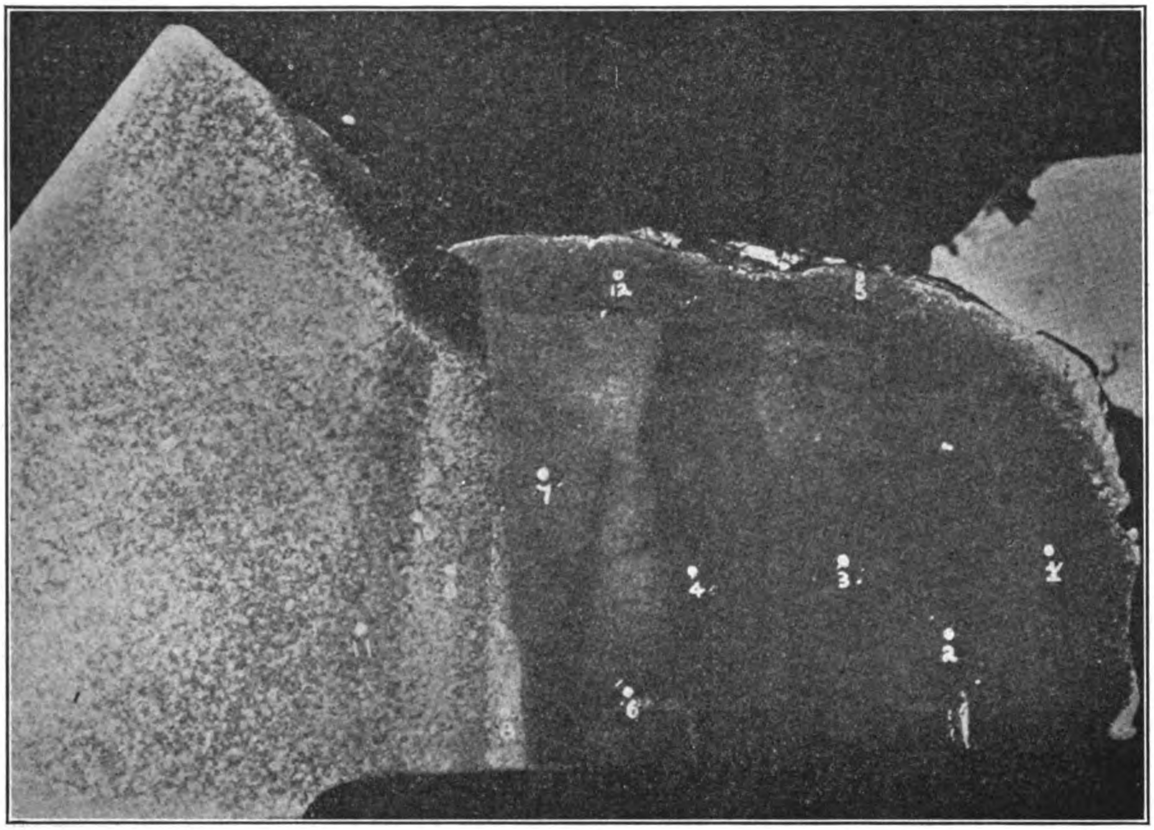

Fig. 1—Electric weld made with covered electrode. The microscope shows different structures at each of the numbered spots. It is usual to find widely different structures in different parts of a weld, especially if it is a heavy piece.

As thermit welding is usually applied only to large sections of steel, and as these applications are neither as numerous nor as various as those of the other two methods, it will be well to give more attention in the present paper to these latter than to the former.

Fusion Welding Practice.

Success in the use of either process depends on several things, but principally on restricting their application so that impossible or dangerous jobs shall not be attempted. It is quite natural for an enthusiast in welding to apply his pet process to everything in the hope that it will be successful, but from a standpoint of safety the enthusiast should be restrained from doing things that fundamentally are incorrect. Unfortunately, we are not in a position to state positively what are the fundamental principles and practices of welding, although much progress has been made in successful applications. A consideration of what actually occurs during welding, as far as it is known, may be of assistance in enabling us to determine how far we should go in using these processes.

In the first place, fusion welding is simply the making of a casting of whatever metal is being welded. The conditions which will permit of sound castings being obtained in the foundry are fairly well known. The melted metal must be protected from oxidation, and care must be taken to prevent cold shuts and other defects. The metal must not be overheated and a proper alloy must be used if good castings are to be obtained. Other precautions will naturally suggest themselves to those familiar with foundry practice. In fusion welding, the conditions for the making of a good casting are largely absent. The melted metal is exposed to the air with chances of becoming oxidized or absorbing gases. It is very easy to produce laps and cold shuts; metal is easily overheated and the constituents such as carbon, zinc, tin, etc., are readily removed; also as the weld is a casting it has all the defects of a casting, even when of the best quality. It is coarse grained, has low elongation and has comparatively little resistance to alternating stress and shock, so that when two pieces of forged metal are united by welding, it cannot be expected that the same results, either physical or chemical, may be obtained in the welded piece as existed in the forged piece. Again, any heat treatment to which the piece had been subjected is destroyed for a certain distance from the weld by the heat; and again, a metal so affected cannot be equal to that which has not been heated. In view of the above facts, it is evident that for safety and success, the maker and user of welded parts should use good judgment in the application of the processes.

You are particularly interested in iron and steel and the consideration of welding of all metals would take more time than is at my disposal. I feel it would be well to confine our attention to the welding of iron and steel, first, in a general way, and second, with regard to a few specific points which may be of special interest to you.

Fusion Welding of Cast Iron.

The welding of cast iron is easier than that of any other metal, and the results obtained are better, except possibly in case of cast aluminum, where the results are just as good. In welding cast iron, any material that is to be added should be of such a character that the application of heat will not burn out the carbon and silicon to such an extent as to make the weld difficult to machine. This means that it should contain a considerable proportion of silicon, this being the first constituent to disappear under the heat. Ordinary machine iron is entirely unsuitable for the purpose, and it is usual for a good cast iron welding rod to contain at least 3 per cent of silicon. When this metal is melted into the weld, it produces a fine-grained structure lower in graphitic carbon than the material being welded, because it is applied in small quantities and cools rapidly. A properly welded piece of cast iron will always break outside the weld. The principal difficulty in cast iron welding is in taking care of the shrinkage or contraction, which of course cannot be avoided, although it can usually be allowed for by expanding other parts of the piece, or by setting the pieces farther apart than they were when broken. The proper methods to follow to avoid strain in the welded piece, due to expansion and contraction, require close attention and much experience on the part of the welder; and even with the greatest care cracks occur at times. It is quite possible that there will be heavy strain in the welded piece, which, however, will not be great enough to cause trouble until it is put in service, when the additional strain due to this may cause it to break. Chilled iron is readily welded, although, on account of its brittleness, the difficulties from expansion and contraction strains are increased when compared with grey iron. Malleable castings dare not be melted, and therefore are not capable of being welded, unless they can be annealed, which is usually impossible. It is therefore customary to join broken parts of malleable iron by using a manganese brass, or a similar alloy, which will unite with the malleable iron at a temperature below its melting point. The joint so made is strong and ductile and answers every purpose. Of course, if the malleable iron be melted, it will revert to chilled iron and lose its strength and ductility. Even the use of manganese brass will to some extent change these properties, but not sufficiently to cause trouble in practice.

Fusion Welding of Steel.

Fusion welding of cast steel is done in many instances as repair work in the steel foundries, and if properly done the results are entirely satisfactory. This is of course largely because the piece being welded is a steel casting, as is the weld. Welding of forged steel in the shape of plates, sheets, bars and shapes is done to a very great extent, especially in manufacturing. Such products as barrels, range boilers, pressure vessels of all kinds, steel tubing and many other products which will occur to you, are made in large quantities with entire satisfaction by fusion methods. Steel is the most difficult metal to weld and with some varieties I do not believe it is possible by any fusion process to get results that are more than moderately good. It is not common to attempt to weld steel of higher carbon content than about .25 per cent and it is not wise in my opinion to place any dependence on welds made in high carbon steel. The lower the carbon content the better the results, and the welding of structural steel changes its physical characteristics so much that great care should be taken to allow for the change if any great strain comes on a piece. The difficulties in welding steel are the same as those encountered in welding other metals, but are aggravated by the high melting point, the rapid solidification and the great change in the structure and physical properties of the metal due to the high temperature to which it is subjected during the welding process, as well as to the fact referred to before that a weld is only a casting. We all know that the lower the carbon in steel the more severe treatment it will stand, either mechanical or by heat. For instance, a piece of soft flange steel may be quenched from a high temperature, may be cold worked by bending and may be forged through a much wider range of temperature than a piece of tool steel. In other words, the former is much more rugged than the latter. Now, in welding, particularly with long seams or irregular shapes, there are introduced all of the elements of distortion and overheating which seriously injure high carbon steel. It is therefore evident that it is wise to confine ourselves to the use of as low carbon steel for welding purposes as is possible, and practice confirms this opinion.

The best steel for welding and one which is commercially available at reasonable cost is probably of about the following composition: Carbon .15 per cent maximum; manganese .30 to .60; sulphur not over .05; phosphorus not over .04.

Its physical characteristics will be about 50,000 pounds tensile strength, yield point about 30,000 pounds per square inch and elongation at least 30 per cent in 8 inches. Of course, such material is not suitable for structural steel, but for pressure vessels it is advisable as will be explained more fully later. The ideal weld would be one in which the structure and the chemical and physical properties were identical with the piece being welded; it is evidently impossible to obtain this in any case regardless of the processes used or of the welding wire employed. We are therefore restricted to either one of two courses; we must either make the weld stronger than the piece being welded, or we must assume or find by experimenting the efficiency of the weld when it is weaker than the pieces being welded. The weakness of a weld may not, however, depend entirely on its tensile strength. This may be higher than that of the pieces being welded and still the weld may be weaker in its resistance to alternating stress or shock. These latter stresses are the ones to which welds are least resistant, so that, even if the tensile strength of a weld is equal to that of the base metal, the weld may be much weaker when stressed in any other way than by pure tension; for instance, in a boiler or pressure vessel where the stress is alternating, in the steering knuckle of an automobile, or in its frame. Evidently, also the design of a welded piece may be bad, if the weld be made in a place where it is subjected to these injurious stresses, while it might be perfectly safe if the weld were made somewhere else. As an illustration of this, a head should never be welded in a tank with the weld at the junction of the shell and a flat head, if it is to stand any great pressure In riveted construction, it is not possible to avoid flanging of either the head or the shell, but in welding it is simple to design the tank as referred to, that it is quite common practice to make them in this way. The bending stresses at the weld will, however, in the course of time cause it to crack, especially if the head be unbraced. These and similar designs should be avoided because of the peculiarities of welds.

Stresses in welded structures are of course due to the heat of the welding process, and in the case of rigid material where the welded seams are long, these stresses must be largely concentrated in or near the weld. If the weld is not strong enough to resist them, it will break; if it is strong enough, the stresses will be there, as they are in cold rolled or other cold worked material. Such stresses sometimes exist in welded seams until they are subjected to shock such as a blow of a sledge, when the additional stress will cause a rupture. On the other hand, if the base material is not rigid, but very ductile, the stresses will be distributed through it to a greater distance fro mthe weld, so that the stress per square inch is reduced below the danger point. This is especially true if the weld metal is much stronger and stiffer than the base metal, and in my opinion this is the proper way to design vessels or structures subjected to heavy stresses.

Welding Metal for Fusion Welds.

Considering the welding metal to be used, it is obvious that no more than a certain strength and resistance to stresses can be obtained with any given material, even with the best workmanship, and if greater strength or resistance be desired, the weld metal must be altered in character. There is, of course, a limit to this, because with steel, as the tensile strength becomes higher, its resistance to shock becomes less, unless it be heat treated, which is not possible commercially in the case of welded structures. So that dependence must be placed on the character of the metal in the weld without heat treatment. The usual material for gas welding steel is a straight low carbon steel wire of about the following composition: Carbon .06 to .10 per cent, manganese .15; sulphur .03 and phosphorus .03. In other words, it is a very pure low carbon steel. Evidently, the strength in a weld made with this material will be low, and it is found to be about 52,000 pounds per square inch in one-half inch plate. It is clear that if this material be used to weld standard boiler or fire-box steel having a specification strength of from 55,000 to 65,000 pounds, the weld will be weaker than the plate. How much weaker depends on the quality of the weld, which if defective may be very weak, so that it has been customary in the past to speak much of the efficiency of a weld. These efficiencies have been found to range in actual tests from 36 to 80 per cent, varying with conditions and the quality of the weld. It is also evident that if such a weld having 52,000 pounds tensile strength were made in a plate of 50,000 pounds tensile strength, the plate itself would break outside of the weld. In view of the possible defects in welds, due to careless or inefficient welders, or to variations in the strength of the plate, this margin of 2,000 pounds per square inch is not sufficient in my opinion, and a stronger welding metal should be used. Such a metal is found in nickel steel of approximately the following composition, which corresponds to the Society of Automotive Engineers' specification N. 2320: Carbon .20 per cent; manganese, .40 to .60; sulphur, not over .04; nickel, 3.25 to 3.75. This metal gives in the weld about 58,000 pounds tensile strength, although it has less ductility than the weld metal above referred to. However, its margin of strength above 50,000 punds plate is sufficient to throw the strain into the plate because of the latter's ductility, so that the weld itself is not stressed beyond a safe point.

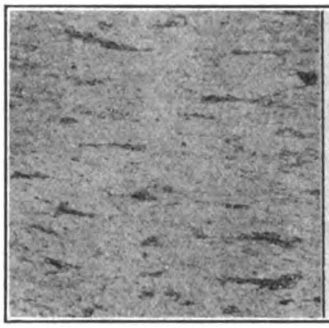
Fig. 2—Electric welding wire, about .15 carbon. Grains are elongated, due to cold drawing, which is necessary for electric welding wire. x200.

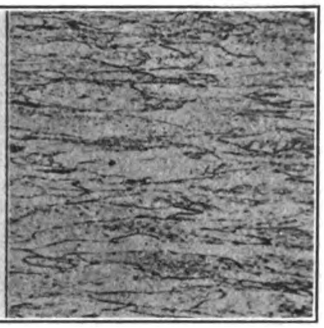
Fig. 3—Armco electric welding wire. Cold drawn. x200.

The strength of the welds given above are for equal sections with the plate, and as it is customary to reinforce welds by increasing their thickness, say 10 per cent or 15 per cent, the strength of the weld is still more per square inch of plate section than the figures given. Economy, however, requires that the weld be reinforced no more than necessary, so that it is still advisable to use some such material as nickel steel in the weld.

Reference has been made to the face that welds are usually over-oxidized castings, and a steel weld is no exception, but it appears that in the case of nickel steel welds the oxidizing is much less. This seems to be due to the formation during welding of a tough, viscous slag, which is probably due to the formation of nickel oxide. This coating on the weld is very thin, but seems to be sufficient to largely protect the metal from the action of the air. Whatever the cause may be, the microstructure of the weld shows it to be much more free from ferrous oxide than ordinary weld metal. It is not necessary that nickel steel be used. Any material will answer that will give equal results. But nickel steel is readily obtainable and, until other alloys are found, I feel that nickel steel should be used for important work.

For electric metallic arc welding a usual composition of welding wire is as follows: Carbon, .15 to .18 per cent; manganese, .40 to .60; sulphur, not over .04; phosphorus not over .04. The exact chemical composition is of much less importance than are uniformity and high general quality. Gas welding wire may be of any reasonable hardness, though it is usually quite soft; but for electric welding the wire must be hard drawn to just the right amount ,or it will not work well. It is only too common to find that part of a shipment sputters and splashes, and will not fuse quietly with the base metal, or that one shipment will be good and another bad. I am inclined to think that this is largely due to the general quality of the wire. That is, its greater or less freedom from nonmetallic impurities, frequently called sonims, and from gases and similar impurities, but the real cause will not be known until just what occurs in the arc is fully determined, which will require much careful and accurate research. The welds made with this material may have a tensile strength of up to 60,000 pounds per square inch. Their elongation is less than that of gas welds and their resistance to shock is less.

Quality of the Base Metal.

It is just as necessary to have high quality in the base metal as in the welding rod. And as this is a matter about which but little has been said, I would like to enlarge somewhat on it.

I might say at the beginning that I have never found a bad welding steel that was not full of sonims, nor a good welding steel that was not free from them, except in one or two instances. I believe it is possible to make a bad welding steel by improperly annealing good material, especially in sheet, where the effect of an oxidizing atmosphere is much greater in proportion than in plate, because of the thinness. The effect is to make the material brittle, presumably by allowing the oxygen to penetrate the grain boundaries, being in effect an incipient burning. It has been shown that by heating in a reducing atmosphere at a temperature below the Ac.1 point, the brittleness was removed, which would seem to show that oxide films at the grain boundaries caused the trouble.

Therefore it seems reasonable that careful attention should be paid to the quality of the steel from the time of the selection of the raw materials, through the furnace processes, during the rolling, and finally while it is being annealed.

The nature of the non-metallic impurities that cause trouble in welding I am not sure of, because they are usually very small, but as the metal just round them seems to be porous to a greater or less extent, it would seem that they must be oxides or silicates. It is also quite probable that the porous part is filled with gases, because bad welding material spits when it is heated to the welding point, indicating that gas has been formed in some way. It is also noticeable that in preparing a specimen for the microscope the later grindings, if done on soft cloth, remove the material around the sonims and give the unetched section the appearance of being spotted with a lot of comet tails, which of course are much larger than the actual size of the particles of impurities. I think it is perfectly safe to say that the microscope will always determine whether a steel will weld properly, exept where it has been put through an annealing process which would damage it at the grain boundaries. I also feel that chemical analysis shows nothing of the welding qualities within wide limits, unless the steel is badly off.

The Skill of the Welder.

Even assuming that steel of good welding quality and good welding material is used, there is always present the question of the ability and skill of the operator. This is true regardless of the process used. While the skill of the operator in any mechanical process is of importance, in welding it is of far more moment, because his work cannot be inspected in any way known at the present time, so that not only his skill but his honesty must be beyond suspicion. It is therefore advisable to have each operator weld test pieces of the size that is suitable to his work and have them tested at regular intervals. In many cases the operator himself does not know what he is doing and the testing of his work will spur him on to do better, if he is the right kind of a man, and others should not be employed on important work.

Much has been said and written about the training of operators, and it is too common a belief that a good welder can be made in from six weeks to three months. It is indeed true that for certain classes of work, such as the welding of sheet steel, the work can be taught to an intelligent man in a short time, provided he receives proper instruction, and it is also true that the time required to absorb a given amount of knowledge will vary with different men, but to enable a man to have a thorough knowledge of welding steel, much longer experience than three months is necessary. There is no process that I know of that looks so easy, and yet is so difficult, to do right as welding steel plates. It is really an art and not a mechanical process. As with all artists, welders may use different methods and still arrive at the same result, a weld free from mechanical imperfections. So that a discussion of welding methods is more or less futile, the only real requirement being a thorough welding of the base metal and the weld metal together. All of these subjects, in both general and specific applications, are being considered by committees of the American Bureau of Welding, which is affiliated through the American Welding Society with the National Research Council, by virtue of its committees being also the same committees of the last mentioned body.

The Cause of Failure.

One of the matters which is of vital interest to all those using welding processes is the cause of failures in welded parts. While there has been no systematic investigation of such accidents, it is probable that those which have caused the most trouble have been in the case of welded pressure vessels, and as these are usually made of steel the subject should be of interest to you. It has been stated before that it is essential in welding by any process to get a thorough union between the weld metal and the base metal, and that it is necessary that the weld be sound. Given good operators and proper welding material, there is no difficulty in obtaining the desired result, but it is of just as much interest to know how results are obtainable, and why welds fail, as it is to know how to make good steel, and why steel sometimes fails. The microscope shows better than any other instrument the nature of the defects in welds, and when this is known, and not until then, precautions can be taken to avoid them. Generally speaking there are two avoidable effects which are in reality one: first, lack of fusion along the side of the V, and second, the lack of fusion in the weld metal itself. The tendency in welding steel is to underheat the plate because it is much heavier in section than the welding wire, in which case the melted wire may fall into the V without being fused to it. The same thing may happen in the weld. When this occurs there is a thin film of oxide between the two layers of metal, and this of course destroys the strength of the piece. In addition to this there is the oxidizing action of the water vapor in the gas welding flame and that of the air on the finely divided metal passing through the electric arc. If the gas welding flame be not properly adjusted, or if the torch be of poor design, there is the additional possibility of free oxygen being present and causing serious trouble. An improperly made weld will show streaks of oxide or other impurities which are frequently very small and thin, and yet the first evidence of distortion of such a weld is at these defects, just as the first evidence of distortion in a piece of steel is at similar defects. During the welding operation these defects appear as bright white spots or streaks in the case of gas welding, which can be floated to the surface and removed. In the case of electric welding this is not possible, except to a limited extent, because whatever impurity is in the electrode must go into the weld. The films or streaks referred to are frequently clearly visible under the microscope, but many times rupture occurs at the grain boundaries in both gas and electric welds, where there are no evidences of any films even at the highest power of the microscope. These ruptures must be at the austenite grain boundaries, because to them the impurities are rejected during the solidification of the metal. In cases of welds where it is possible to distinguish between the gamma and the alpha grain boundaries, as is possible when there is much pearlite, I have never seen a case of rupture at the alpha boundaries. This would seem to be quite natural, because the alpha grains are formed by the recrystallization of the gamma grains, and if there be any impurities at the gamma grain boundaries it is not possible for one grain to grow at the expense of another one past such impurities.

It would hardly be expected that any ordinary heat treatment would alter the character of the ruptures in welds, and if defective welds were heated in an oxidizing atmosphere it might be expected that they would become more brittle. Such tests as I have made indicate that this is true. On the other hand I have found that electric welds which were very brittle as made, were notably improved by heating several hours in a strongly reducing atmosphere at a temperature of about 600 deg. C. This would indicate that the difficulty is one of oxide. The characteristics of welds made by the gas process are their large grain size, their lowness in carbon, manganese and silicon, their maintaining of practically the same amounts of phosphorus and sulphur as in the welding material, and their lack of ductility. It is quite evident that the heat will remove carbon, silicon and manganese, but there seems to be a point in the case of each one of these elments beyond which the reduction does not take place because of the diffusion of them from the base metal into the weld. The same statements are true of electric welds, except that their ductility is less, while their tensile strength is higher when both are made of ordinary material. Welds also offer comparatively slight resistance to alternating stress and shock. Inasmuch as all of these characteristics appear to be due to the presence of oxide, it will be well to consider what means have been taken to prevent oxidation.

Prevention of Oxidation.

Oxidation should evidently be less severe in the case of gas welds than in electric welds. First, because the temperature is not so high, and second, because of the protecting influence of the envelope flame, which is composed of hydrogen and CO burning to water and CO_2. In the electric arc the temperature is very high, and the metal passing over the electrode to the weld is very finely divided, with naturally great oxidation. It will appear clear that if the melted metal could be covered with a protecting slag, oxidation would be much lessened. This has been done for a number of years in electric welding by coating the electrodes with compositions of various kinds which produce slags of various viscosities. If the slag is too viscous it may be entangled in the weld, weakening it, and if too thin it will not protect the metal; but it is a fact that electrodes of this type when properly used give a sounder weld than electrodes made of bare wire. With gas welding no organized attempt has been made to provide such a slag covering. Naturally with the lower temerature a thinner slag will be necessary, but there is also to counteract this the blast from the flame, which has a velocity of about 375 feet per second at the exit from the tip, which tends to blow away the slag and to leave the metal exposed. It is rather curious that nickel steel welding rod seems to provide a very thin slag and produces a weld which is much less oxidized than one made of ordinary low carbon steel. This seems to be due to the formation of nickel oxide. It is noticeable that the scale on a nickel steel weld adheres much more strongly than that on one made of ordinary wire. The microscope shows that this is because of its interlocking with the melted metal. It is entirely probably that before best results will be obtained with gas welding it will be necessary to provide a properly coated welding wire. It might be mentioned incidentally that in the case of non-ferrous metals, such as brass and bronze, much sounder welds are produced when the welding material contains slag forming constituents and when flux is sparingly used, than when other conditions prevail. This would naturally be expected because of the well-known fact that a clean surface of melted metal permits the absorption of gases which are given out during solidification, causing porosity.

While a coated wire doubtless makes a better weld than a bare one, its use is attended by difficulties such as the inclusion of the coating in the weld, and its expense, so that unless the weld must be of superior quality its use is not desirable, and in many cases its use is not necessary either in gas or electric welding. If possible it would be much better to introduce the materials that make the weld clean and sound into the electrode or welding wire, and I think that the ease of doing this is greater with the latter than with the former.

Testing of Welded Pieces.

It has been quite common to make tests of welded pieces usually of comparatively small size in order to determine their strength, but unfortunately in most of these cases the results are either inaccurate, or the conditions under which the work was done have not been given with sufficient completeness to enable comparisons to be made with other tests. Usually nothing is said about the character of the material to be welded, or as it is called, the base metal. It has been stated before that a weld made with a given material cannot have more than a given strength. It is evident that if a weld be made in base metal of 50,000 pounds tensile strength and the weld have a tensile strength of 52,00 pounds that rupture will occur outside of the weld, while if the base metal have a strength of 60,000 pounds, the rupture will occur in the weld. Also, as most of the elongation occurs during the last few thousand pounds in a tensile test, a 52,000 weld in 60,000 base metal will show but little elongation, while with the 50,000 pound base metal the elongation will be that of the base metal itself. Therefore, if the characteristics of the base metal be unknown, no fair conclusions can be drawn from the test. Of course, this is only one factor, and the following information should be given if the results are to be of value:

Chemical analysis of the wire.
Chemical analysis of the base metal.
Tensile strength and other characteristics of the base metal.
Microstructure of the base metal.
Microstructure of the welding wire or electrode.
Tensile characteristics of the welded pieces.
Bending characteristics of the welded pieces, hot and cold.
Size of electrode or welding wire.
Amount of wire used.
Amperes during welding.
Open circuit voltage.
Welding voltage.
Make of torch and size of tip.
Gauze pressure of oxygen and acetylene.

These tests will answer for many purposes, but as welds are more or less brittle and non-resistant to alternating stress, it is almost necessary for complete information to make alternating stress and shock tests. It is not very important as to what machines are used for making these tests so long as the same machines are used where the results have to be compared. It would also be expected that such tests of welds would not be very consistent, and quite a number of tests should be made to obtain a fair average. This is necessary because of the irregular quality of welds even when carefully made. Probably as good a test as any to determine the ability of a welder is the cold bend test.

It is made by making a weld in a piece about 2 in. wide and of a thickness with which the welder usually works. A single "V" should be used and the weld left flush with the base metal. After the piece is cold it should be clamped strongly to the side of the anvil or held in a vise with the bottom of the "V" level with the face of the anvil or the top of the vice jaw. The projecting part can then be struck with a hammer or sledge so as to stretch the top of the weld. The number of blows required and the angle through which the piece bends before breaking or cracking is quite a fair measure of the quality of the weld, but it must be remembered that the character of the base metal again influences the results. Soft ductile material will take much of the bend while hard stiff material will throw the strain more into the weld. Examination of the fracture will show if the fusion has been complete and whether the weld is clean. For a more accurate test the bending can be done in a testing machine by mounting the test piece on supports and forcing a bar of the proper radius against the piece, using the load and the angle to which the piece bends before cracking, as a measurement of the quality.

The hot bend test can be made in the usual way. My experience has been that all ordinary welding materials, both gas and electric, will give in the weld a hot short metal, the hot shortness existing at a bright red heat. I have also found that this red shortness does not occur with some coated wires for electric welding, nor with nickel steel wire in gas welding. This seems to me additional evidence that the brittleness of welds is caused by oxides. It seems evident that a welding material that has no brittle range is quite necessary for use in welding locomotive fire-boxes or similar structures, because where the sheets are overheated, as happens when the water is low, there is much danger of the weld giving way suddenly, and while we all agree that low water should not occur, we also agree that it cannot always be avoided. Therefore, it is wise to use some welding material that will reduce the danger.

In gas welding of cast iron it is permissible to use a tip that is large in proportion to the size of the casting, blocking up the edges to keep the melted metal from running away. But in steel welding by gas, too large a tip will make the metal boil and foam, and is certain to injure the weld. Also in electric welding of steel too heavy a current must not be used. On the other hand too small a tip or current will result in imperfect fusion and a bad weld. This is spoken of because of the tendency in production work to increase the output by forcing the welding, as such a forcing always causes trouble in the quality of the product.

The welder is frequently given all the blame for defective work, and it is true that in many cases he is responsible, but before criticising him too severely, we should consider whether the real responsibility may not lie in other directions. Those in authority should remember that welders as a rule are anxious to do good work. In fact, it is very rare to find any welder who is not eager to learn more about his work, and willing to do anything that will improve it. It is quite common to find crude or defective apparatus in shops that would not think of furnishing apparatus of such a character for other processes, and no mechanic can be expected to do good work without satisfactory tools. Again, those in authority are generally unfamiliar with welding, largely because it is a new process and opportunity has not been afforded them to appreciate the necessity for good apparatus and proper conditions under which to do the work. I believe it is generally true that the management of any shop where welding is used, knows less about it than about any other process they employ. Furthermore, most engineers, not being familiar with the peculiarities of welds, make their designs to suit other forms of construction with which they are acquainted, such as riveting. There are very few welders who have received any real instruction in their work, but have simply picked up what they could. It seems to me evident that the first place this instruction is required is in the management. I do not mean that superintendents or foremen should be expert welders, but they should have a sufficient knowledge of the principles and practices of welding to be able to tell whether the work is being done as it should be done. If they realize their responsibility they will see that proper designs are prepared and the proper apparatus and materials are furnished and used in the proper way.

Another thing that should receive attention is the proper training of operators; and men should be selected with regard to their fitness for the work. Good eyesight is essential and is too often disregarded. The methods of training would differ in different cases, and no more can be said in a general way than that a good foundation should be laid with regard to the fundamentals of handling the equipment. After this is acquired, such training should be carried out as will fit the man for the work he has to do, bearing in mind that routine work requires much less knowledge and experience than is necessary for an all around welder.

Effect of Welding Heat on Base Metal.

All welding operations effect the base metal as does any other method of applying heat, but as the heat is more local, the distance from the weld that is so effected is less than in forge welding. As a consequence the changes in structure may be compressed into a very short space. In any form of welding the heat must be supplied at a greater rate than it is removed from the base metal by radiation and conduction, and in fusion welding it is supplied very rapidly. In the case of electric arc welding of a ¾-in. plate the entire range of change in structure may be found within about 1/16 in. of the line of the V, while in gas welding plates of the same thickness they will occupy about 1½ in. from the line of the V. These changes consist of a coarsening of the grain where the heat is greatest at the line of the V, the coarseness gradually decreasing until a zone is reached where the grain size is the same as that of the original plate. If the plate has been finished at a higher temperature than that due to its upper critical point, beyond this zone there will be a refinement of the grain until the place is reached at which the temperature has been that of the Ac3 critical point, where the grain size will be finer than that of the plate, beyond this again the grain size will increase until it is the same as that of the plate. Beyond the Ac3 line the plate has been subjected only to a drawing heat, which might alter its physical characteristics without changing the grain size. In the electric weld in the ¾-in. plate referred to, which contained between .25 per cent or .30 per cent carbon, there was a marked increase in scleroscope hardness in the zone next the weld, and evidently the greater the carbon the greater would be this increase. In the gas weld referred to, the increase was not nearly so noticeable, being only one or two points, which might be due to other things. The grains next to the weld in the electric weld were sorbitic. Here again is an argument in favor of using low carbon steel for welding, because the effect on it is much less than with higher carbon steels. In fact, in cases of shafts which require metal added to them to take care of wear, it is advisable to preheat them to a black heat to avoid the chilling effect which would otherwise occur. It has been found, for instance, that in adding metal to the crosshead fit of locomotive piston rods, there is danger of the rod cracking at the edge of the weld because of the more brittle structure at that point, unless they are preheated. The coarseness of the grain makes the metal less resistant to shock and decreases its ductility, and though in many cases this is of little importance, it should always be considered.

It would naturally be inquired whether heat treatment would not remove the effects of the heating due to the welding, and it may be said that this is quite possible, but in most cases too costly, because the Ac3 point of the weld is quite different from that of the base metal, both because it contains less carbon and also because it is a casting. This means that for the best results a double heat treatment must be used, the first one at a high temperature, say 1750 deg. F. This, of course, coarsens the grain in the base metal, and it is then necessary to reheat it to about 1450 deg. to refine the grain of the base metal. It seems, therefore, clear that except in unusual circumstances it is not commercially possible to heat treat welded pieces. It should be noted that the annealing to which such parts as shells of tanks are subjected for the purpose of relieving the welding strains, will not alter the structure as a usual thing. Of course, it is theoretically possible to use a welding material that will require in the weld the same refining temperature as that of the base metal, but I doubt if it is a practical solution, because difficulties would arise in its use, if it were plain carbon steel. On the other hand it might be possible to produce an alloy steel that would answer the purpose. Therefore, unless in special instances, the designer of welded parts should not consider the possibilities of heat treatment, but make his designs to suit welds as they are made.

The physical changes in the character of the weld metal have been referred to and it might be well to consider the chemical changes. Any ordinary welding material is low in carbon, that for gas welding having about .06 per cent and that for electric welding about .15 per cent, yet there is always a loss of carbon due to the heat, so that the weld made with such materials does not contain over about .03 per cent or .04 per cent of carbon. Manganese and silicon are also lost, but as would be expected the phosphorus and sulphur do not change. In the case of heavy welding the loss of the above elements is less near the V than in the center of the weld, as there is some interchange of the elements between the weld metal and the base metal, so that in sampling a weld for chemical analysis care should be taken to keep away from the edge of the V, unless proper allowance is made.

While there is a loss of some elements there is a gain in both oxygen and nitrogen. Nitrogen in both gas and electric welding comes from the air, while the oxygen probably also partly comes from the water vapor in the envelope flame in the case of gas welding. It is generally believed that molecular nitrogen has but small affinity for iron at even high temperatures, and this is doubtless true. On the other hand iron ordinarily combines with nitrogen in the nascent condition at 1400 deg. F. as has been proven by numerous tests.

Effect of Nitrogen on the Weld.

There has been much discussion as to the effect of nitrogen on steel, some taking the position that it makes steel brittle and others that it has very little if any effect. The presence of nitrogen as nitride can be quite accurately determined by chemical analysis, but its existence in other forms, such as dissolved gas, cannot be proven in this way. It is usually believed that when it is present in sufficient quantity it combines with the iron, making an iron itride having the formula Fe_2N. In this condition it may be seen as a constituent of the metal in the form of plates lying along the cleavage planes of the grains, and with larger quantities is present as a eutectoid of iron and iron nitride at the grain intersections.

Electric arc welds have the same structure as iron N-ized, except that the structure is much finer because of the rapid cooling. Gas welds may also contain the plates when the metal has been overheated. Similar plates are also visible in samples of Bessemer steel taken just after the blow and before recarburizing. In all three cases the metal has been overheated, and it would seem to be quite possible for nitrogen to combine with iron as iron nitride at these very high temperatures. Of course, there is as yet no mechanical proof that the plates are iron nitride, as they have not been isolated. It is not worth while to discuss the matter here, except as to whether nitrogen is responsible for the brittleness in electric welds made with bare wire.

Direct Process For Steel Manufacture

The Possibility of Using Oil Lignites and Other Fuels—The Blast Furnace and the Direct Process Compared

By A. E. BOURCOUD

PART I

THE subject of this paper "Direct Steel" has formed the basis of speculation and research for the last fifty years with very little to show for it in practical results or constructive theory. This is true notwithstanding the fact that the problem cannot be considered as more difficult of solution than others of a strictly chemical or metallurgical character which have been solved during the same period of time. It may, therefore be considered that investigators have not approached the problem in the right way, or they have failed altogether to take advantage of the data and scientific facts to be deduced from blast furnace practice.

In the following paper the author will endeavor to outline the theoretical requirements of the direct steel process and indicate the possibilities of a successful solution on an industrial scale.

Resumé.

The present paper does not claim scientific nor technical merits of any kind. The author has unpretentiously prepared in a more or less schematic form, some suggestions conducive to the commercial realization of the socalled direct process for steel-making from what appears to be a new point of view.

The conclusions derived from this preliminary survey, give great encouragement and it is believed would justify the semi-industrial scale experiments needed to confirm in a practical way the theories advanced.

The conclusions can be summarized as follows:

(1) That the gasification of atomized oil and powdered coal of any kind presents great possibilities for generating economically, in large industrial units, very powerful reducing gases, emerging from the producer at a sufficiently high temperature for immediate use in reductive operations.

(2) That the economic reduction of iron ore by a current of gases with the employment of working agencies based on the continuous impingement of the gases on the ore, shows great possibilities of large-scale operations, delivering continuously spongy iron, at high temperature, ready to be melted in furnaces of standard types.

(3) That the combined economic efficiency of both operations would make possible the establishment of the iron and steel industry in places where present methods have little chance to work commercially owing to the lack of coking coals, as is the case in California, Texas, Black Sea, and other localities possessing oil; Brazil and Italy, with lignites, and many more with good non-coking coals, like France.

(4) That even in the actual steel districts, the employment of powdered coking coal in the combined suggestion can show favorable economic results competively with our present routine.

Direct Processes in General.

The "Direct Process," used as a term for describing the manufacture of iron by the conversion of iron ore into sponge and then into commercial iron and steel in a single direction, i. e., without passing through any other intermediate commercial product, has been the goal of numerous investigators for many years. The simplicity of the chemical process involved has at all times possessed a strong fascination for inventors and others; and the mere enumeration of the solutions advanced or tests carried out would fill a fair-sized book. Unfortunately, for the advance of the art, none of these experiments were fully successful as regards application of the principle on a commercial scale to compete with the economic results obtained by the present methods.

These investigations lost, in past times, most of their interest and importance after Bessemer's famous invention, which left to the direct process very narrow economical limits within which to develop. In more recent times, from the first serious endeavors of Dr. Gurlt in Bonn, in 1857, up to the most recent attempts, in 1920, all the processes have been complete industrial failures, because although C. W. Siemens, in 1868; Chenot, in 1870; Adams and Blair, in 1885; Stassano, in 1900; and Gröndal, in 1909, succeeded in manufacturing iron, it was by dint of the use of very pure ores and with a prohibitive cost of manufacture, which placed these processes entirely out of the question, irrespective of their relative merits.*

Reviewing past work on this subject, it might at first sight appear strange that taking account of the few factors entering into the direct solution, no perfected process has resulted. The reason for this becomes apparent in comparing previous attempts in direct steel. All experimenters have followed a more or less beaten path, those who came after, arriving ultimately no nearer a solution than those preceding them—in fact, in the most recent trials, the same errors in theory and practice have been duplicated.

Abstract of paper presented before American Iron & Steel Institute, November 18, 1921, New York.

It will be just to make here one, and a unique, exception, in the continued commercial success of the Sieurin process, worked by the Hoganas-Billesholms A.B.—in Halsinborg (Sweden) with a yearly production of about 8,000 tons of sponge iron of high quality, since 198. However, the special local economical conditions and their derived advantages do not make the process suitable economically for any other locality, as has been demonstrated by the repeated attempts to adopt it in several countries and distinct districts of Sweden. The process works in crucibles and cannot be considered as a solution of the direct process problem, industrially speaking.

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A consideration of individual cases indicates that past failures of direct processes are not due to the impracticability of the system, but rather to the misconstruction placed upon laboratory experiments and the application of laboratory conditions in large-scale application. It is doubtful whether the direct process can be built up in this way, depending entirely on theoretical consideration based upon laboratory experiments, as interpreted today.

Blast furnace operation brings to view in one of its steps the possibilities of the direct process solution, although covering by the characteristics of its system an excessive range. In the opinion of the writer it has many possibilities to be solved by entirely different means, with the additional advantage of suppressing the intermediate and contaminative zone which forms the link between the reduction of the iron oxide and the melting of the reduced iron, the two real achievements of the blast furnace.

The Direct Process Problem.

Direct process investigations and propositions are generally received by a large majority of iron masters and industrial iron metallurgists with marked indifference and suspicion, considering the issue as being a futile and pedantic attempt to replace and outshine our modern blast furnace—the base of our steel industry—with all its accumulated improvements, large tonnage production, long practice and established traditions. This assertion has to be modified for lack of proper foundation, as it does not represent the real situation in either its true industrial form or its purely scientific aspect.

Cast iron is the principal commercial product of the blast furnace. Taken alone as a process for the direct manufacture of cast iron, it is universally recognized as one of the most perfect metallurgical working agencies in existence. Its present state of development has practically reached its final stage, leaving very little opportunity for further improvement. This is the aspect of the critic of the direct process but it is not the issue.

The greater and by far the most important industrial use of cast iron is to serve as raw material for conversion into steel, either by the Bessemer, the Open Hearth, or by any other process. With this application, the blast furnace, broadly speaking, becomes in its greater field of action, an adjunct to the steel plant, losing all its individual economical characteristics, becoming a part of a more complex system of manufacture, whose merit has to be judged by the collective work accomplished by the whole group as a single unit, and not by any particular one of its components. This is the true aspect of the question and the real issue.

Marion Howe has said that cast iron is a grade of steel. The trouble is that the blast furnace goes further than necessary, passing during the course of its work through the steel grade of steel without any stop, to arrive finally at the cast iron grade of steel, and the product has to be brought back, with extra fuel, labor, capital investment and the inevitable loss of metal.

To appreciate at first sight to what extent these drawbacks are influential in the industrial results, nothing is better than to suppose, for the moment, that the blast furnace, with the same amount and kind of fuel, labor, material and expenses, were able to produce directly, the steel grade of steel instead of the cast iron grade of steel which it usually produces — the former being a product necessitating, notwithstanding, less reductive work and the same general conditions.

Comparing this direct steel blast furnace with the combination of the cast iron blast furnace and the open hearth, or even the converter, it would be found under ordinary conditions, that per ton of melted final product, the ratio of fuel consumption would be as 100 to 125; the total capital investment as 100 to 175; the cost per ton without profit, but with the usual fixed charges, as 100 to 135; and finally, taking the minimum market value at which the product manufactured by the combination can be sold, the return on the total capital investment would be 42 per cent and 6 per cent per year respectively. It is these comparative industrial aspects that furnish the reasons for the exiting incentive for possible improvement.

In comparatively recent years interest in the research on direct production of steel in accordance with modern lines has been revived, and a few eminent metallurgical authorities like the late Prof. Wedding, of Berlin; J. O. Arnold, of Sheffield; A. Standfield, of Montreal; and J. W. Richards (recently deceased), of Lehigh, Pa., have had the courage of their convictions in maintaining an independent attitude notwithstanding the general indifference, especially of those who should ultimately be the ones directly and materially benefited by any valuable contribution.

The Blast Furnace and Direct Processes.

To start with, and to be quite fair, it should be mentioned that the blast furnace—of which we are so justly proud—was not invented with the intent of producing cast iron, but rather it is the natural evolution of the old Osmund and Stuckofen types of furnaces, which were nothing more than the results of vain attempts during the thirteenth century to industrialize the Catalan Forge, with the main object of producing sponge iron in large quantities, but finding, instead, a new and unexpected form of final product.

When cast iron appeared in the fourteenth century, it was the most undesirable and unwelcome product to the iron makers of the day, as they did not know what to do with the new metal and how to handle it. The changed method was accepted, however—even though it was not all that was desired—as being a more economical solution and providing larger reducing units for treating iron oxides. It, however, created new and important problems to be solved, at the same time giving birth to the real metallurgical inventions which were found necessary to convert the cast iron back to soft iron again, the soft iron being the final product sought.

The finery, the puddling, the converter, the open hearth and all its modifications have followed, meanwhile the blast furnace firmly established as their raw material purveyor, improved rapidly up to its present state, keeping always within the original and fundamental lines. It is today the solid base of our huge steel manufacture, together with the Bessemer converter and the Siemens-Martin furnace variations.

Reviewing in general the action on the charge through the different working zones of the blast furnace, it can be divided into three main stages (1) preheating, preparatory to reducing; (2) reduction by gases, practically completed; (3) prepartory overheating, completion of reduction, and melting, through a very strong reductive fusion. The work is continuous, the stages overlapping each other, with the appearance of a flexible arrangement, but forming in reality a rigid system without elasticity or independence.

Considered from a chemical engineering point of view, the most important and complete of the different stages, is the reduction of the iron oxides by the ascending current of gases; it is perfect in action, constant and reliable; its practical results have never been duplicated in any of the numerous attempts made in the direct methods. It is the fundamental operation of the blast furnace, and its highly efficient work has made good and acceptable the other inconveniences typical of the system.

Of the remaining two stages, the first or pre-heating, is not only incomplete, but harmful to certain elements due to its overlapping and reducing influence; the third, or overheating and melting operation as it is carried out, is the main cause of the extreme difference between the two products—cast iron and steel—due to the reduction of undesirable elements by the unavoidable presence and contact of large masses of solid carbon at the critical moment where it is less desired.

We may conclude from this preliminary survey that in order that a direct process may take due advantage of the blast furnace experimental data, all the above mentioned working stages must be planned as independent operations and independently regulated so as to establish a flexible system which will at the same time be more adaptable to varying conditions. The first stage or preparatory heating has to be improved; the second or reduction has to be duplicated, if possible; and the third or melting, radically changed.

Such an arrangement means a complete departure from blast furnace lines, inasmuch as the two final products demanded are so fundamentally different, although so near in their generic form. This necessity has been recorded by the majority of experimenters.

By adopting a proper pre-heating operation under decided oxidizing influence, we have the necessary improvement of the first stage, and by melting with modern agencies under special atmosphere and out of contact with any fuel, we can change radically the third. Then the stages first and third can be satisfactorily arranged in the right direction with only our present knowledge, experience and approved working agencies.

With reference now to the second stage, how and with what means it should be possible to effect, under the new conditions, a positive duplication of the practical results of the reduction carried out in the blast furnace, is what in reality constitutes the backbone of any direct steel proposition, as has been recognized by all previous investigators.

It is within this scope that the problem is considered here in this unpretentious essay, and a possible solution suggested with all the appearances of a practical realization, under the economic conditions required to place the process on a favorable competitive basis with our present methods of manufacture.

Both methods of carrying out the reduction have their respective partisans, and have been the subject of many controversies in the numerous trials and experiments since the first attempts made in the direct proposition.

Without discussing and questioning here whatever might be the merits and advantages of the employment of solid carbon intimately mixed with the iron ores, it is a recognized fact that the complete reduction of the ore in the solid state with only the agency of solid carbon in order to obtain a solid deoxidized product, is physically impossible owing to the lack of adequate cantact of the reducing agent with the inner part of the grains of ore, no matter what is the degree of fineness of the grinding and the homogeneity of the mixture. The practical results obtained with this method of procedure are, however, due to the beneficial influence or action of the gases evolved in the operation. Were it not for that help, the reduction would be faulty and incomplete. If the gaseous phase takes such an important part in the most critical period of the penetration and completion of the reaction, there is no doubt that the whole operation can be carried out also with gases alone, provided these gaseous reducers are placed in the right and necessary conditions to do thorough work as is the case of the blast furnace.

The present investigation belongs to the class of processes based on the employment of gaseous reducing agents alone, without contact of any kind between solid fuel and the ore charge, either in the reduction or the melting operations.

AWARD SAFETY DIPLOMAS TO FOREMEN.

Graduation exercises in McCreery's Restaurant, Pittsburgh, Thursday evening, November 17, marked the conclusion of the largest and most successful Foremen's Safety School ever conducted by industrial plants in the United States. The graduating class numbered approximately 750 and each graduate received a diploma from the National Safety Council.

This safety school, for foremen of industrial plants in the Braddock District, was inaugurated by the General Superintendent of the Edgar Thomson Steel Works, O. J. H. Hartsuff, and was originally intended for the instruction of his own foremen in safety matters. Later, however, Mr. Hartsuff widened the scope of the course to include foremen from all the industries of the district, and the various plants of the district were represented on the committee which had charge of arrangements: John B. Trusel (Edgar Thomson Works), Chairman; J. A. Oartel (Carnegie Steel Co.), J. E. Lose (Carrie Furnaces), Thos. Crombie (McClintic-Marshall Co.), S. Baum (Columbia Steel Shafting Co.), John D. Price (Wilson-Snyder Pump Co.), Peter Toner (American Chain Co.), A. R. Blainer (Consolidated Expanded Metal Co.), A. M. Kremkau (Copper Clad Steel Co.), John Hockenberger (Benner Tool Co.), E. M. Paterson (Duquesne Light Co.), L. H. Lesimore (Nicholson Chain Co.), Jas. Weeks (Pittsburgh Machine Tool Co.), Jos. Tronsberg, Jr. (Acheson Mfg. Co.), B. D. Peters (Rankin Works, American S. & W. Co.), George Garver (Braddock Works, American S. & W. Co.), Jos. Connor (Sterling Steel Foundry), D. R. Ferguson, J. A. Morgan, David Scott, F. A. Power, F. H. N. Gerwig, Jos. A. Lawler, John Lloyd and F. F. Slick, all of Edgar Thomson Works, W. Milroy (Union Railroad), and F. R. Wilhelm (Pittsburgh Railways). All meetings were conducted by E. S. Willis of Wilkinsburg, Pa.

The auditorium of the Braddock Carnegie Library was packed to capacity for each session of the course, which consisted of addresses on safety subjects by Dr. R. M. Little (N. Y. Industrial Commission), J. A. Oartel (Carnegie Steel Co.), John Martin (Ohio Works, Carnegie Steel Co.), F. H. Trego (Pittsburgh), E. Friedlaender (Edgar Thomson Works) and Dr. Wm. T. Dorward (Milwaukee).

Relation of the Iron and Steel Industries to the Chemical Industries

Review of the Chemical Products Consumed by the Steel Industry. —Steel and Chemical Industries Are Closely Allied

By JAMES M. CAMP
Director, Bureau of Technical Instruction
Carnegie Steel Company, Pittsburgh, Pa.

CLASSIFIED according to their direct relations to our natural resources and with respect to their dependence for raw materials, our industries are basic or subsidiary, according to the way they are grouped, and dependent. The basic industries are those engaged in the production, or creation, of raw materials by life processes, such as farming; or in the extraction of raw materials from the earth, such as mining or oil and gas-well drilling; or in the conversion of natural potential energy into useful forms, such as our hydroelectric plants. But these industries must be supplemented by a number of others, which, although they are directly dependent upon these basic industries for raw materials and mechanical power, are so intimately related to the former by reason of their being engaged in converting and adapting certain raw materials for use that they must be accepted as coordinate to these basic industries and also coordinate to each other. Hence, all these closely related industries are to be looked upon as being subsidiaries to our industrial life as a whole.

To explain more fully what we mean to imply by this use of the term "subsidiary" it is necessary to point out that we apply this designation to groups of closely related industries rather than to any specific activity. Thus farming, for example, is really a class term, for under it are included such occupations as gardening, cattle raising, fruit growing, and the growing of grain, also the sciences that relate to these arts. From this standpoint we are able to separate our industrial life into a number of divisions, which we shall term the subsidiary divisions of industry. For want of better names, we designate the basic subsidiary division devoted to the production of raw materials by life processes as the agricultural division; that devoted to the extracting of raw materials from the earth as the mining and well-drilling division; and that devoted to the transforming of natural energy as the hydroelectric division. As to the dependent subsidiaries, we call that one devoted to the separation and refining of the metals the metallurgical division; the one devoted to the preparation of refractories, bricks, all clay products, as well as glassware, etc., the earth-products division; and that devoted to the production of chemical compounds, the non-metalic elements, and certain of the rare metals, the chemical division. Some of you may think of other industries that should possibly be included as another division, but we believe that any of our industries can be placed under one or another of these divisions.

One of the things we wish to emphasize now is the close relation and interdependence of all these grand divisions of industry. So we would call your attention to the accompanying diagram, which will both demonstrate and vividly illustrate the point we wish to make. This diagram shows that these subsidiary divisions of industry are closely connected and related to each other because they are dependent upon each other for necessary raw materials and supplies, and are each made up of a number of related industries so important that they are usually spoken of as being, themselves, the basic industries. Each of these industries is accompanied by a list of dependent industries so long that it was found impracticable to show them on this diagram. It is such a subsidiary division of industry, not a small branch of industry nor yet one of the dependent industries, that we have in mind when we refer to our chemical industry. It consists of the chemical industry proper and a great number of dependent industries, which, though they are not engaged primarily in the production of chemicals as such, produce articles of a chemical nature, or by chemical processes, or articles that depend mainly upon chemicals. The chemical industry proper has, itself, three branches, which are known as the chemical section, the acid section, and the coal-tar section.

Referring to the other part of our theme, we see in our country today a single branch of the subsidiary metallurgical division developed to such a high state of efficiency, and on that account occupying such a high position commercially that it casts a shadow over the importance of even the subsidiary divisions. Such an industry is the steel industry. And here lies great danger for us, in that we may be led to attach too much importance to one industry or one division of industry and not enough to the others. Trying to decide which of these grand divisions of industry is the more important is like trying to decide which wheel of an automobile is most important, for they form the vehicle upon which our civilization is riding towards that goal set up for it from the beginning, when man was commissioned to replenish the earth and subdue it.

As we consider these relations, we feel like an artist must feel when he gazes upon the beautiful sunset, the raging storm, the mighty ocean, or the clear blue sky, and realizes that here is a changing beauty, here a host of forces, here a vast expanse and depth, and here an endless space that he can never paint. For

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Paper read before the fall meeting of the American Iron & Steel Institute, November 18, 1921, New York City.

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if our industries are as interdependent as we have shown them to be and if the relations of our industries to the future peace and progress of this nation and to the health, comfort, prosperity and happiness of its people are what they seem to be, then, indeed, we do have to deal with very important matters in the direction indicated by our subject. All our material progress is largely a matter of progress in our industries. And whatever disturbs one division of our industries disturbs all our industries. In short, our industrial prosperity depends upon the maintenance of a certain balance among all divisions of industry; and with abnormal conditions in one we cannot have normal conditions in any. The limits of time, of our capacity, and of your patience will not permit us to set forth these themes in their entirety, but like the artist who is glad to select a few colors from the sunset, a rolling cloud from the storm, a little section of the ocean surface, or a little speck of space from the sky to indicate what he hopes that those who view his pictures can supply from their own knowledge and imaginations, so are we glad to be able to present to you a picture of the relations between only a few spokes in two of our industries, which hitherto have represented the front wheels of progress.

As the most important branch of the metallurgical division of industry, the steel industry cannot escape certain relations with the chemical industry, and it is interesting to note that these relations, both direct and indirect, are to an unusual extent interdependent. This interdependence is most vividly set forth when we consider these two industries from the standpoint of being consumers of each other's products.

In reviewing the chemical products consumed by the steel industry, we find that sulphuric acid heads the list both as to quantity and importance. Statistics showing the quantity of this acid consumed by the whole steel industry of this country have never been compiled. We do know, however, that during the year 1920 the United States Steel Corporation used approximately 280,400 net tons, all of which was concentrated to give, on an average, a gravity test of 60 deg. Baumé. This fact leads us to the confident belief that our steel industries as a whole must have consumed last year at least 600,000 net tons of this acid, expressed on the standard gravity basis of 50 deg. Baumé. To make a striking comparison, the acid consumed during the year 1919 by the Steel Corporation alone amounted to almost 10 per cent of the total quantity of this acid reported by the Census Bureau as having been made in this country that year. Of this acid used by us, nearly one-half finally went into the manufacture of ammonium and iron sulphates and thus represented a recoverable outlay, but the remainder represented an actual consumption, from which there was no such recovery of acid or any other direct tangible return for the outlay. As to the direct purposes to which we put the acid, not used in the manufacture of ammonium sulphate, a small portion was used in washing benzol and other homologous compounds produced by by-product coke plants, a smaller portion was consumed in making chemical analyses, and the remainder was employed for pickling. The pickling process consists in immersing the steel in a warm dilute solution of the acid, and has for its purpose the removal of scale from the surface preparatory to tinning, galvanizing, cold rolling, cold drawing or chipping.

Concerning the necessity for pickling, this operation, as all of you know, is absolutely essential in the manufacture of steel wire, of tin and terne plate, of galvanized sheets and tubes, of cold drawn seamless tubing, and of all sheets requiring a highly finished and polished surface; and, as a means of revealing surface defects in billets and blooms, it is a great aid in the manufacture of high grade steel, such as that required for forged and heat treated articles. Other agents could be used for some of these cases, but the cheapness, chemical activity and high volatilization temperature of sulphuric acid make it the most satisfactory reagent that can be employed for this purpose.

The next items in point of quantity consumed by our corporation during the year 1920 were muriatic, or hydrochloric, acid and sulphur itself. Of the 10,200 net tons of the former consumed, some was used for pickling in processes where sulphuric acid is not suited to the conditions, such as the final pickling in galvanizing; some was consumed in our chemical laboratories, where it is used in practically every analysis made; some was neutralized with zinc to form part of the flux used in the manufacture of tin and terne plate; and a small portion was applied to various other purposes too numerous to mention here. The greater portion of the 22,000 net tons of sulphur used by us was consumed in the manufacture of sulphuric acid, which we also make as a by-product in zinc smelting, but a considerable portion was employed in the manufacture of certain grades of steel, in the galvanizing of sheets, and in the erection of acid-proof water-tight brick tanks.

The fourth and fifth items next in importance are salammoniac, or ammonium chloride, and soda. During the year 1920 our corporation required almost 7,500,000 pounds of salammoniac and a little more than 1,120,000 pounds of soda, most of which was in the form of the hydroxide, commenly known as caustic soda, and the remainder in the form of the carbonate, or soda ash. The salammoniac was used chiefly as a flux in the application of tin, terne and zinc coatings, but a small quantity was consumed in the laboratories and shops, where it is indispensable in some work. With the exception of small amounts used in our laboratories and for cleaning purposes, the soda was employed in our plans for the neutralization of acids and corroding compounds, such as in the washing of benzol products and the softening of water for boiler use. Its effectiveness and the importance of its use for these purposes are matters that need not be elaborated upon nor emphasized here.

Other items that may be of interest to certain organic chemists are the 6,000,000 pounds of palm oil used in the tin plate plants of the corporation during 1920, the 63,477,000 gallons of fuel oil consumed, and the 3,264,000 gallons of straw oil required for the absorption of benzine and its homologues from our coke oven gas. Tar oils may be substituted for the straw oil, but no satisfactory substitute for the palm oil has yet been found, though such a substitute has been diligently sought.

A small item is nitric acid, of which we consumed nearly 6,000 pounds in 1920. The use of this acid is restricted to laboratory purposes almost exclusively. During the same year, our requirements for the nitrate of soda called for more than 3,500,000 pounds of this salt, most of which was employed in the manufacture of sulphuric acid.

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Manufacture of Wire for Wire Rope

A General Description of the Methods Used in Manufacturing Wire for Wire Rope

By CURTIS VOIGTLANDER,* M.E.

SO LITTLE has been published and so little is apparently generally known about the manufacture of wire, that a description of the usual operations of this important branch of the steel industry should be quite acceptable.

The steel used for rope wire is usually the best acid open hearth steel and varies in carbon content from .30 per cent to .80 per cent according to the grade of wire to be manufactured.

As the rolling of billets and of wire rods has been frequently described in technical journals, we will start with the rods delivered to the wire mill, and show how the wire is manufactured.

No. 5 BWG is the smallest rod that can be rolled with a fairly circular section.

The No. 5 rods in coils weighing from 150 to 250 pounds are delivered to the tempering or "patenting" furnace of the wire mill and placed upon the reels or "swifts" to allow uncoiling.

The furnace is from 30 to 60 feet long and is fired with coal, oil or producer gas. The rods are run through the furnace, where they are heated to from 1400 deg. to 2000 deg. F. Then out into the air and on to the revolving iron drums or "blocks," which wind up the rods, pulling them through the furnace.

Both the temperature of the furnace and the speed of the blocks are regulated according to the size of the rods or wire, and according to the carbon content of the steel, so as to give the best "temper," as determined by long experience. If an exceptional strength is wanted, the rods are often cooled more quickly on coming out of the furnace by running them through a pan containing melted lead. This is the so-called "lead tempering."

The tempered rods are next pickled in the cleaning house in dilute sulphuric acid to remove all the scale. They are washed and dipped into a lime bath to neutralize the acid and to prevent rusting while drying.

The rods are then dried in a dryer for several hours at a temperature above 212 deg. F. When thoroughly dry they are pulled out and placed at the swifts of the wire drawing benches.

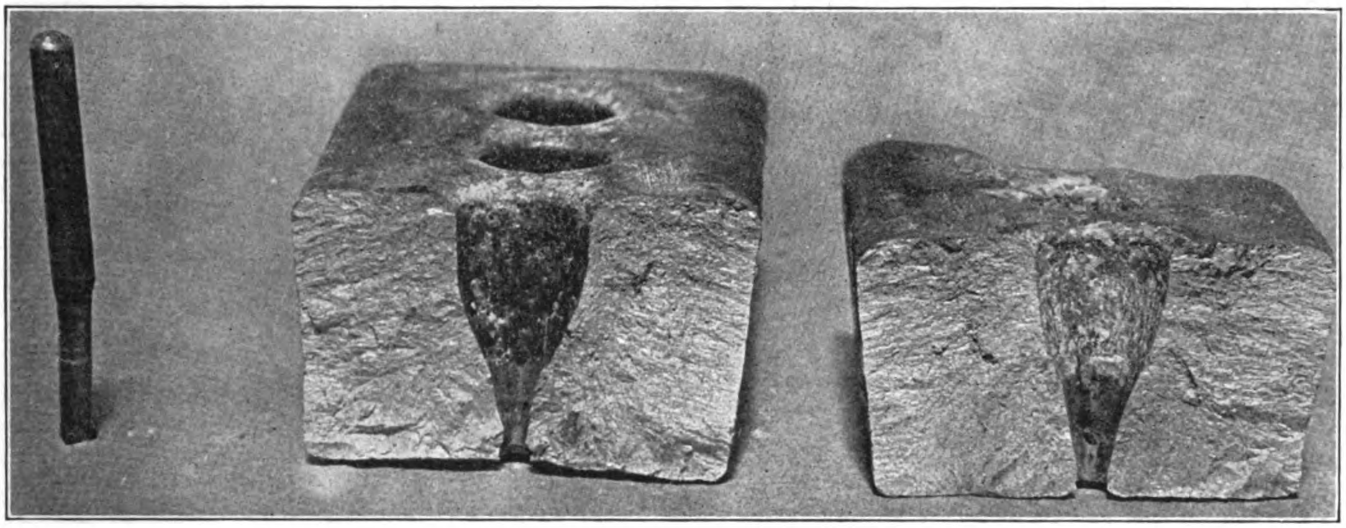

Fig. 1.

The wire drawing blocks are very similar to those on the pull out frame of the tempering furnace, except that they are heavier, and each one has a clamp at the top. After the coil of rod is placed on the swift and the end pointed by means of a special pointing machine, the end is inserted through the hole of the cast iron die, and a few feet of wire drawn through by means of a pair of traveling tongs. The die is fastened in a suitable stand in front of the block with a compartment in front of it for powdered soap, which lubricates the rod or wire as it enters the hole. The end of the wire just pulled through is clamped fast to the top of the block, and the clutch is kicked in. The block revolves and as it winds up the wire, pulls it through the die, reducing the wire to the diameter of the hole and lengthening it proportionally. This operation is repeated through a smaller hole in another die in front of the next block, etc., until in from three to seven or more reductions or drafts, the rod is reduced to a predetermined size. If the required size is large enough to be drawn from then worked cold, the tapering hole punched with a hardened steel punch and reamed or "set" to size with the rod, no further treatment is necessary, and the coil is called "finished wire." This is then weighed and carefully tested for breaking strain, bending, torsion, elongation, etc., and is ready for the rope shop.

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*The author is with the George C. Moon Company, Garwood, N. J.

The holes in the dies are made by a die reamer, a man long skilled in his work, as the holes have to be perfectly smooth to make smooth round wire. The holes have a gradual taper ending in a cylindrical section. The sizes resulting from each draft are carefully calculated in advance to obtain the required properties of the wire.

Fig. 1 shows two sections of a cast iron die broken in half to show the shape of the hole. A piece of wire which has been pulled through the die, cut off and pulled back out of the hole, is also shown.

Drawing wire hardens and strengthens it, until a point can be reached where it becomes brittle. Consequently, there is a limit to the size that can be finished right from the rod. When finer sizes are to be drawn, the wire from the first drawing is again put through the tempering furnace, where it regains its elasticity and is softened or tempered. The usual cycle of pickling, drying, drawing and testing is then repeated.

In drawing the medium and fine sizes of wire, the cast iron dies are rarely used for many reasons, the chief one being that it is more difficult to ream accurate holes of the finer sizes.

Steel plates or wortles are used, which have the holes punched hot to the approximate size. These plates are a hardened steel "set."

The operation of drawing wire gradually enlarges the hole so that the last end of the coil of wire may be 1/1000th inch larger than the front end.

In cast iron dies the hole must be reamed to the next larger size until finally the hole becomes so large that the die must be discarded and remelted to make a new batch of dies.

The plate or wortle, however, being elastic steel, is hammered all round the back of the hole, closing it up a few thousandths of an inch. It is then again punched to shape and reamed or set to size as before.

Still finer sizes of wire must be drawn through still harder steel plates, usually made of chrome or tungsten steel.

The extremely fine sizes are drawn through a hole made in a diamond, the hardest substance known. The reason for this is that the fine wire is so tough and unyielding that a hole made in the hardest of steel dies would not last long, and it is very difficult to make this hole except with the most delicate and accurate instruments.

Cast iron dies have from three to 16 holes according to the size of the die.

Steel plates are usually punched with three rows of holes, six holes to the row.

A wortle is a small plate punched with one row of from two to seven holes.

Diamonds are, of course, very small, and have only one hole. The diamond is usually set in a circular brass disc about the size of a quarter and four times as thick.

Foreign Methods of Roll Design*

English Roll Turners Follow Rule of Thumb Methods Rather Than Theory—Results of Investigations Made by America and Germany in Roll Design.

By R. H. RONNEBECK, B.Sc.

IN DESIGNING a set of rolls, it is our object to convert a rectangular ingot into the finished section in the least possible time and with the least possible expenditure of energy. It is done in three stages—cogging, roughing and finishing. We have to decide the number of passes, the amount of reduction in each, and the arrangement of the passes on the rolls. It is generally desirable to use as few passes as possible with a view to saving time, but an exception to this is often made when it is desired to use the same roughing rolls for two different finished sections. Saving in time means that the bloom has less time to cool, and is, therefore, softer and easier to roll; it also means greater output.

In cogging, the reduction at each pass is generally limited by the diameter of the rolls.

Figure 1 shows the deciding factors as to whether the ingot will be drawn into the rolls or not. The critical condition occurs when the resultants of the frictional forces F and the radial forces P are vertical. The critical angle A differs according to various authorities. Karl Lang, a Hungarian writer, gives A 35 deg. for roughened rolls. Hirst gives A 30 deg. while Geuze gives A 22½ deg. The last named is equivalent to a reduction of one-thirteenth of the diameter of the rolls. Dehez states that the higher the temperature of the bloom, and in the case of first forming passes, the sharper the V shaped grooving of the bloom, the better the rolls will take hold.

A common method is to start from the desired finished section and work back to find the proper size of bloom to which the ingot must be cogged. Some skilled designers prefer to select the size of bloom by judgment, and then design the following passes so as to gradually approach the finished section.

Design of Cogging Rolls.

A great amount of latitude is permissible in designing cogging rolls. The sizes of the largest ingot

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*Paper read before Cleveland Institution of Engineers, Middlesbrough, April 4, 1921.

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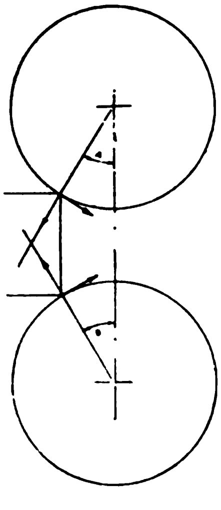
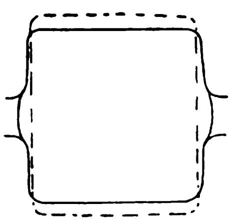


Fig. I



FORMATION OF FIN ON BLOOM.

Fig. 2

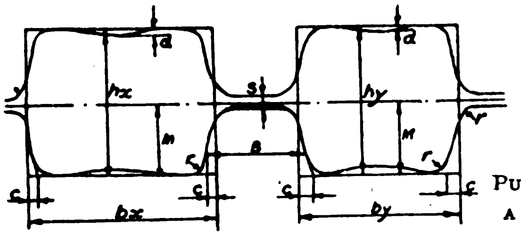
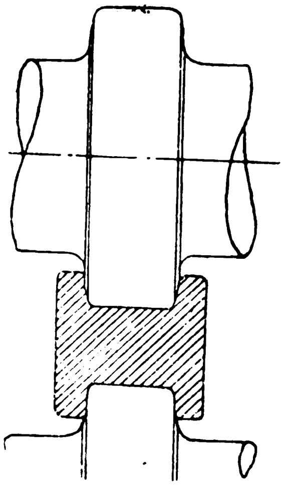
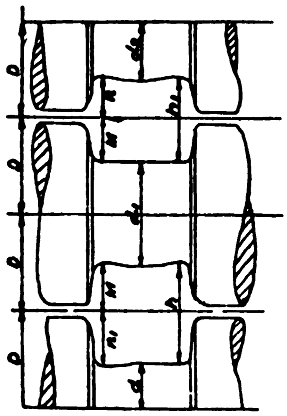


Fig. 3



PUPPE'S 1ST FORMING PASS PREPARING A BLOOM FOR HIS UNIVERSAL MILL.

Fig. 9



$$M = \frac{h + h_1}{4}$$

$$n = \frac{3h_1 - h}{4}$$

$$n_1 = \frac{3h - h_1}{4}$$

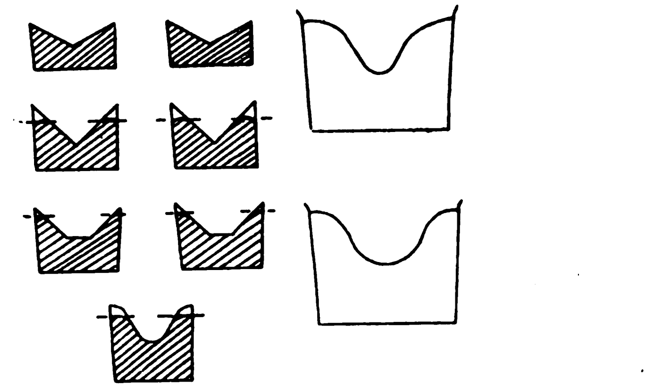
$$d_1 = D - \frac{h + h_1}{2}$$

$$d_2 = D - \frac{3h_1 - h}{2}$$

$$d = D - \frac{3h - h_1}{2}$$

BILLET ROLLS FOR THREE-HIGH MILL.

Fig. 4



CALCULATED AND ACTUAL FILLING OF HOLES

GOOD AND BAD TYPES OF 1ST FORMING PASS

Fig. 5

and the smallest bloom must be taken into consideration. It is often desirable to be able to roll slabs, and this limits the depth of the widest groove. The actual amount of reduction is generally given by screwing down the top roll.

The reason for the increased diameter of the rolls in the centres of the grooves is shown in Fig. 2. When a bloom is rolled with a heavy reduction, the sides bulge out. This would cause the bloom to "fin." By making the sides concave to start with this is avoided.

This Figure is copied from Hutte, and gives the proportions of the cogging roll grooves for a two-high reversing mill.

Fig. 4 gives the same for a three-high mill.

The roll diameters in the case of a two-high mill may be equal, or the bottom roll may be made a little larger, say ¼ in. to ⅝ in. with a view to protecting the roller trains. The slightly larger bottom roll caused the bloom to be curved upwards, especially at the ends. The bloom will not strike the rollers with such force if this is done.

After being cogged down to a suitable rectangular section the bloom has its rough ends sheared off and then enters the roughing mill. Here it is given a shape approaching the desired finished section. There is no hard and fast line between the roughing and finishing stages. The first forming pass, as its name implies, is the pass in which the bloom departs from its rectangular section. There are many different ways of roughing and finishing a given section, which I will deal with further on. There are certain definite principles connecting the shape of the first forming pass, and the rectangular bloom which is to enter that pass. As these principles hold good in the following passes, I will deal with them now.

For all commoner sections, such as channels, joists and rails, the first forming pass necessitates rolling a groove in either the top or both the top and bottom sides of the bloom. It is in this pass that the heaviest reduction and the greatest change of shape can be given. We, therefore, require to know the limiting factors governing the size of groove we can successfully roll in the bloom. It is obvious that the centre of the bloom is more heavily reduced than the side portions. The elongation must be proportional to the reduction provided that no metal flows out sideways. What actually happens is that all the parts undergo the same elongation. Tafel, a German engineer, found from a series of experiments that the actual elongation in any pass was the mean of the elongations which the various parts of the section would undergo if they were not connected together. That is, the central portion in the case we are considering is held back by the outside portions, and the outside portions are dragged out by the centre. To equalize matters a certain amount of flow takes place from the centre to the outside. We must design the shape of the groove to facilitate this flow if we wish to economize in power. The figure shows a good and a bad form of groove. You will see that in the bad form a large amount of metal must flow suddenly from the heavily reduced centre to the sides of the section. If we attempt to roll too large a groove, the elongation will be so great that the hole will not be filled at the sides. The following method of finding to what height the hole will be filled is due to Tafel, and is based on the experiments I have just mentioned.

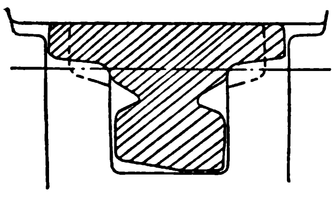

Swabbing Hole For Spreading Flange of Rail.

Fig. 7

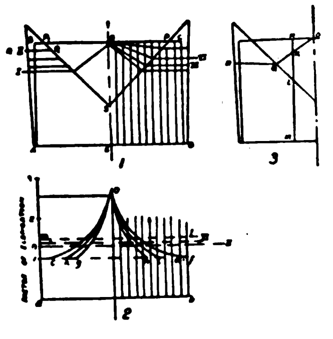


Fig. 8

Suppose a bloom of section A B C D is to enter a hole as shown on the figure. The bloom is divided vertically into a number of equal parts. The theoretical factor of elongation of each part is plotted in the figure below. The portion of the section outside the points P_1 and P receive no roll pressure and the ratio of original to final length is, therefore, unity, which is represented by the height, a 1 in the diagram. At the point O the section is reduced to S. The corresponding elongation factor equals E O divided by E S, which is 2.57. This gives us the point O on the lower diagram. Points between S and P are similarly treated, and we get the curves O C and O d. Now the mean elongation factor is the mean height of the area a 1 C O d f b. This mean is the height a m and according to Tafel's law is the actual elongation factor of the whole section. We therefore draw R Q so that the area A R Q S E multiplied by this elongation factor equals the area A B O E. But this cannot be the correct filling of the hole, because we started with the assumption that the section from P_1 to P was under roll pressure. Looking for a moment at Fig. 2 you will see that the section at H is reduced to L. Now assuming that R Q is the actual filling of the hole and joing O Q, we divide the reduction into two parts. H K represents the reduction due to the extension of the bloom by the centre part and K L represents the reduction by actual roll pressure. We are at present only concerned with the latter. Turning back to Fig. 1 we have just found that the bar is under pressure only from S to Q. We, therefore, plot a fresh curve of values of K M divided by L M, giving us the figure a 1 g O h f b. The mean height is a n. From this we draw a second level marked II so that the area enclosed multiplied by the mean height a n is equal to the area A B O E. Again, this cannot be the correct filling, because it shows that the roll pressure is exerted over a different width to what we have assumed. But if we repeat this process a few times we will finally obtain a level marked VI, which is correct. Now this, you will say, is a very tedious process, but by estimating the level as nearly as possible in the first place, we can easily check it by this method, and so eliminate much of the work. I have described it in full so as to demonstrate the principle involved as clearly as possible. In practice the lower diagram can be dispensed with by simply tabulating the values $\frac{\text{K M}}{\text{L M}}$ and finding their arithmetic mean. With the aid of a planimeter the problem only takes a few minutes.

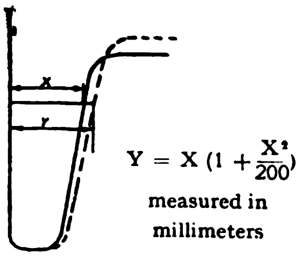
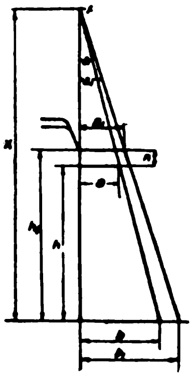


Fig. 11—Reduction in closed hole.

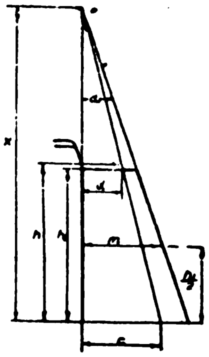


Given h tan α a b Q (area)
n = 5mm. (constant)

1. $X = \frac{b}{\tan\alpha}$
2. $h_1 = h + n$
3. $\tan\alpha_1 = \tan\alpha\ (1 + \tan\alpha)$
4. $a_1 = (X - h_1)\tan\alpha_1$
5. $b_1 = X\ \tan\ \alpha_1$
6. $Q_1 = h_1\frac{a_1 + b_1}{2}$

3a. $\tan\alpha_1 = \tan\alpha\ \left(1 + \frac{\tan\alpha}{2}\right)$

Fig. 12—Design of open hole for flange or joist.



Given h tan α d c Q_1.
(Q_1 is the same as found for the corresponding open hole.)

7. $h_1 = h - \frac{1}{2}$ to 1mm.
8. $m = \frac{Q_1}{h_1}$
9. $\tan\alpha_1 = \frac{m}{X - h\frac{1}{2}}$

Fig. 13—Design of closed hole.

This method is correct, no matter what the shape of the groove, provided that the angle at the bottom is not less than 50 deg. or 60 deg. With a sharper groove a certain amount of cutting takes place, and the hole is filled more than the calculated amount.

If the hole is wider than the bloom in order to allow for spread, it will, of course, not be filled so high. This can easily be allowed for by multiplying the mean value of $\frac{\text{K M}}{\text{L M}}$ by the width of the bloom, and dividing by the mean width of the hole.

The previous figure shows how accurate the method really is. The full line shows the actual filling, and the dotted line the calculated amount.

When the bloom is grooved on both the top and the bottom, it is only necessary to divide the section in half horizontally and then to proceed as above.

This method can also be used in the design of swabbing passes for rails and T bars. A swabbing pass is a pass in which only a part of the section is given any reduction. The reduced part cannot elongate because it is restrained by the remainder of the section. It is, therefore, compelled to spread. The figure shows how this is utilized to form a wide flange on a rail. Swabbing passes should be used as little as possible, because no work is done on the bulk of the section, and it cools considerably. I would point out here that the work done in rolling a bar is converted into heat, which materially assists in keeping up its temperature.

Now a few words on that bugbear of the roll turner-spread.

When any section is passing through the rolls it not only elongates, but widens. This increase in width is called spread. Very many attempts have been made to reduce spread to a mathematical formula, but so far without complete success. Geuze in his book on the "Rolling of Iron and Steel," published in 1900, gives a graphical method of determining spread. But under certain conditions, his method gives negative results, which are, of course, impossible. Further on in his book he ignores this method, and simply says that spread is equal to .48 of the draught for iron and .36 of the draught for steel. This is also correct in certain cases.

It has been found by experiment that spread depends on the draught, the diameter of the rolls, and the temperature of the bloom.

Brovot's formula neglects the diameter of the rolls, and cannot, therefore, be correct.

Ernst Scheld and Adolf Falk agree in stating that the temperature of the bloom has no effect on spread. They say that springing of the rolls under the higher pressure caused by a cold bloom accounts for the apparent effect of temperature. Scheld gives a formula

$$\text{Spread} = \frac{d}{50}\cot.\alpha \qquad \text{Kirchberg.}$$

$$\text{"} \quad = \frac{A\,d\sin\alpha}{h_1} \qquad \text{Scheld.}$$

$$B = \sqrt{\frac{9.23\,d\,b\,(h_1 + h)}{h_1\,\beta} + b^2} \qquad \text{Falk.}$$

Where b = width before pass. B_1 = width after pass.
h = height before pass. h_1 = height after pass.
d = draught = $h - h_1$. α = arc of contact in degrees.
β = arc of contact for $h_1 = O$ (rolls closed).
A = length of arc α.

COMPARISON.

24-in. Mill					Kirch-berg.	Scheld.	Falk.
h=120	h_1=100	b=100	α=14.7°	b_1=	101.5	104.0	105.4
120	100	200	14.7°	"	201.5	204.0	205.4
60	50	100	10.4°	"	101.1	102.0	103.9
60	50	200	10.4°	"	201.1	202.0	203.9
36-in. Mill							
120	100	100	12 °	"	101.9	104.0	106.6
120	100	200	12 °	"	201.9	204.0	206.7
60	50	100	8.5°	"	101.3	102.0	104.8
60	50	200	8.5°	"	201.3	202.0	204.7

Fig. 9.

which, invariably does not work out correct. Falk claims that his formula

$$b_1 = \sqrt{\frac{0.161\,d\,b\,(h_1 + h)}{h_1\,\alpha}} + b_2$$

where b_1 = width after the pass
b = width before the pass
h_1 = height after the pass
h = height before the pass
α = arc of contact in radians with rolls closed.
d = draught = $h - h_1$

covers every case that he has tried. He also agrees with Scheld that spread is independent of the nature of the steel and speed of rolling as well as of temperature. Numerous tests at different temperatures all gave the same result. But it is pointed out that the case is quite different if the temperature of the bloom is uneven. This would be the case if the bloom were allowed to cool in the open. The inside would be far hotter and softer than the outside. The harder shell would offer great resistance to elongation, but not a greatly increased resistance to bulging at the sides. The result is that the spread of a chilled bloom is greater than if it were at an even temperature throughout.

Most authorities agree that spread is independent of the initial width of the bloom. Falk's formula does not agree with this as you see, but the effect of "b" in the formula is very small. This formula is not merely rule of thumb, but it is the result of a long and elaborate mathematical process based on first principles.

Tafel has evolved what he calls the "Depth Influence Theory." He finds that spread only affects the bloom to a certain depth from each side. Hence the name. This theory is very similar to Falk's, except that he considers that every part of the cross-section of the bloom except the vertical centre line, contributes to spread. Tafel considers that there is a central area which contributes nothing to spread, but all to elongation. Tests appear to substantiate Tafel's idea, but the real difficulty is that there is no means of calculating this depth, so this theory hardly carries us any further.

$$\text{Spread} = \left\{\frac{2\,E - e\cot A + \beta}{100 \qquad\qquad 2}\right\}$$

which simply means that spread equals one-fiftieth of the draught multiplied by the cotangent of the angle of contact with the rolls, but he admits that this is only approximate. He uses it in his examples of joist and channel passes drawn at the end of his book.

Dehez, a man who devoted his life to the study of rolling, does not agree with Falk and Scheld that temperature has no effect on spread. In order to ensure the complete filling of "closed holes," he allows a spread of .25 to .3 of the draught.

W. Trinks, an American professor, has written many articles concerning roll design and spread in "The Blast Furnace and Steel Plant," to which I must refer you for further particulars.

The fact is that most of the formulae for spread give fairly accurate results for the range of conditions which

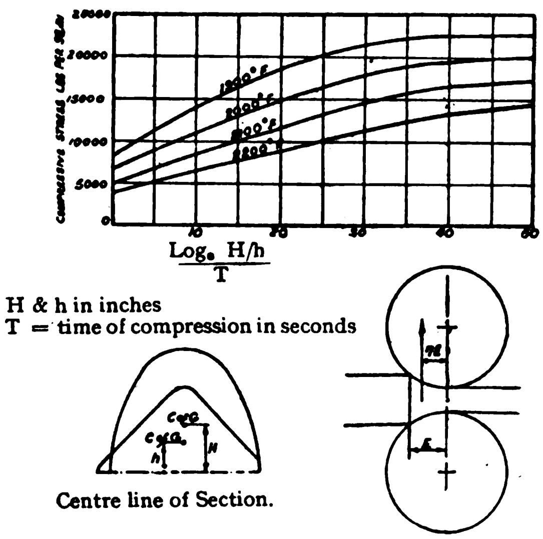


Fig. 10

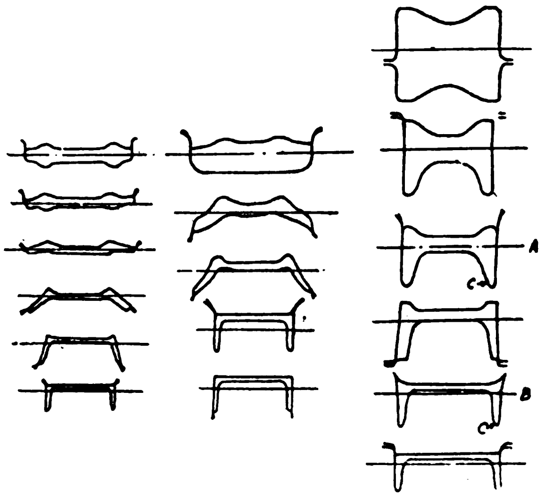
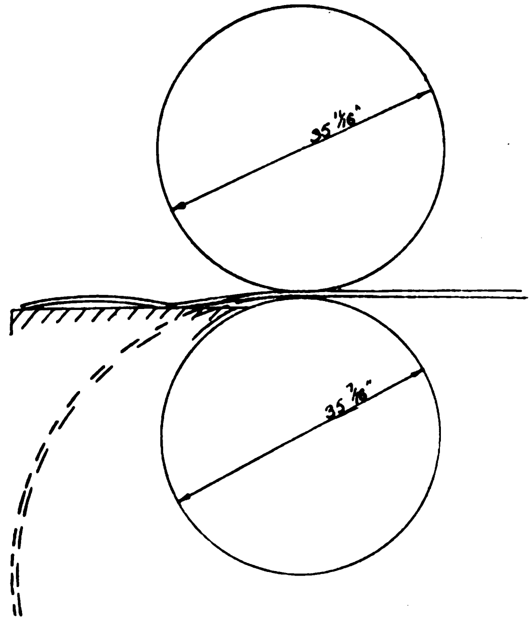


Fig. 4. Sample passes "bending-up" method of rolling channels. Fig. 6—Sample passes combination method of rolling channels. Fig. 5—Sample passes "counter" flange method of rolling channels.

Fig. 16



WAVY ROLLING OF ½IN. FLAT IN 36IN. MILL.

Fig. 17

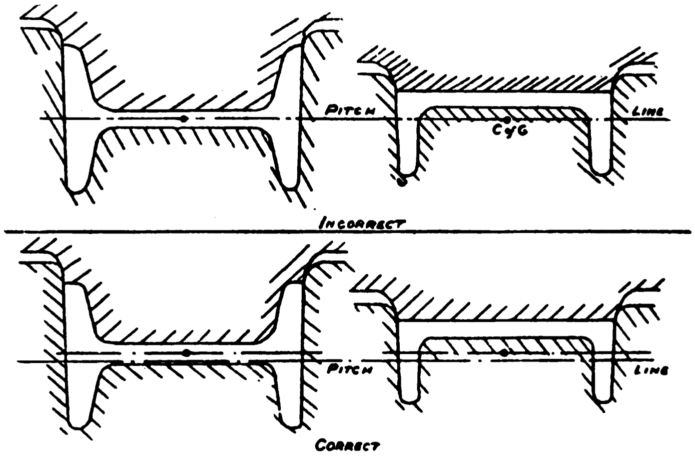


Fig. 18

they are intended to cover. They fail when applied outside these ranges.

I now propose to deal with the actual design of rolls for joists.

We must begin by choosing the maximum possible reductions. We are not tied to the rule of proportional elongation in the earlier stages of roughing. Steel will stand an enormous amount of distortion provided it is of good quality and above a certain temperature. Puppe demonstrated this in rolling blooms which were to be finished in his famous universal mill. This slide shows his design. You will see that the web is enormously elongated, and the flanges are simply dragged along with it. In spite of the predictions of failure of many roll turners, this design was quite successful, and no cracks developed in the bar. Incidentally it is interesting to note that no collars are required to ensure that the bloom remains symmetrically between the rolls. I suggest that the action of the rolls on the bloom is in this respect similar to that of the crown of a belt pulley on a flat belt.

In finding our maximum reduction we have to consider the strength of the rolls as regards bending.

The next figure shows the pressure per square inch of projected area of contact between the bar and the rolls.

The stress in the rolls follows the usual formula:

$$f = \frac{M}{Z}, \text{ Z being the section modulus.}$$

For steel $Z = \frac{1}{10} d^3$, but for cast iron it is $\frac{1}{10} d^3$ because cast iron does not follow Hooke's law. The strength of a roll depends largely on the radius of the fillet at the bottom of any grooves in it. To allow for this the stress "f" must be multiplied by 10 for a sharp corner, by 3 for ¼ in. radius, 2 for ½ in., and 1½ for 1in. radius. Trinks recommends a factor of safety of 3, which is equivalent to a drop in temperature in the bloom of 350 deg. F. below the normal. For cast steel rolls he gives a yield point of 40,000 lbs. per sq. inch, and 75,000 lbs. per sq. inch for forged nickel steel. For cast iron rolls the limit he assigns is 25,000 to 28,000 lbs. per sq. inch. I believe there would be fewer breakages of rolls if this calculation were carried out in all cases where sufficient strength is doubtful.

The rolls must also be strong enough to withstand the torque which can be estimated from the assumption that the centre of pressure between the bloom and the rolls occurs as shown on Fig. 10. To this must be added the friction of the roll necks. This total must, of course, not exceed the maximum driving torque. It is also assumed that the housing will stand the strain .

In practice the reduction is generally limited by the fact that the rolls will not bite if too much is attempted, especially is this the case in the cogging mill.

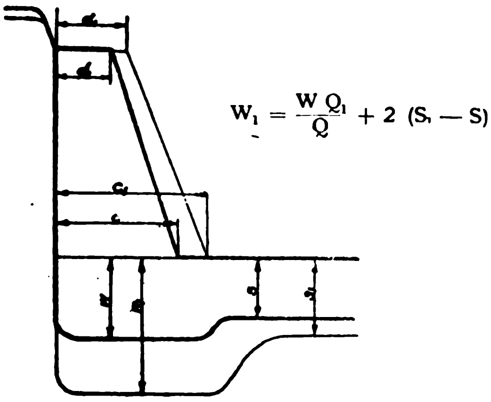


Fig. 14—Proportions of counter flange for channel pass (Kirchberg).

An American firm carried out experiments a few years ago in order to ascertain the best arrangement of reduction passes in the cogging mill. They found that the best results were obtained by commencing with a small reduction and increasing it gradually to a maximum in about five passes. The bloom was then tilted, and the same treatment repeated. This method was very effective in preventing the formation of cracks. The reason given was that the steel was only subjected to severe deformation after the grain had been broken down small. Once this had been done the reductions gradually decreased as the temperature fell. Kirchberg is very strongly in favor of decreasing the reduction factor in such a way that it follows a parabolic law. His method of designing passes for joists and channels is worth describing. He bases it on the tangent of the angle of the finished flange combined with a parabolic formula, and he works back from the finished section. The use of the parabola allows for the fact that the plasticity of the steel decreases with the thickness and with the temperature. As he starts with the finished section he talks about the "increase" and "coefficient of increase" instead of about reduction. The coefficient of increase must be the same for both web and flanges for any one pass. The deciding factor is the closed hole which must be designed within 5 per cent limits. The figure shows the formula used and its application. In the right hand figure both top and bottom must be regarded as closed holes. In passes with open holes the flanges can be given a heavier reduction, up to twice as much as for closed holes.

The next two figures show the methods of designing open and closed holes for joist and channel flanges. The cross-sectional areas Q_1 for any one pass must be equal and closed holes alternate with open holes. The web is given the same reduction in area as the flanges and spread is allowed for by using Kirchberg's formula given on Fig. 9. For the last hole but one, i. e., the first hole to be designed equation (3) of Fig. 12 is modified to (3a). The formation for the closed hole remains the same.

After the consideration of joist flanges, channels involve nothing new, and the same formula can be used. But to avoid a too rapid cooling of the corners (owing to no work being done on them) what is known as the "counter flange" is used.

Fig. 15 shows this and gives its proportions.

Having determined the chief dimensions of the passes it only remains to round off the corners.

This figure shows how this is done, and also gives the necessary taper of the holes.

You will see from the formula $y = X \left(1 + \frac{X^2}{200}\right)$ that if the finished flanges are to have straight sides, all preceding holes must have more or less parabolic sides. The distances E and E_1 are therefore marked off according to the formula $E = \frac{b^2}{200}$ and $E_1 = \frac{c^2}{200}$. From these points A and B parabolas A F and B F_1 are drawn tangential to the flanges. For this Kirchberg uses a French curve cut to a parabola having the equation $x^2 = 10y$ drawn in centimetre units. For open holes the apex A is placed tangential to the flange so that the curve runs through F, and for closed holes the point B is tangential to the flange.

For channels R is the same as for joists, but the other radii must be made somewhat smaller.

The method outlined above can generally only be used up to and including the 7th hole. Beyond this the draught may easily be too great for the roll diameter. The remaining holes can be calculated from the following formula:

Given h_1 a_1 $\tan \alpha_1$, b_1

$$h_1 = h \ 5\text{mm}$$

$$a_1 = a \ \frac{a^2}{200}$$

$$\tan \alpha_1 = \frac{a_1}{X - h_1}$$

$$b_1 = X \tan \alpha_1$$

Widening E, rounding off and tapering (s) is done as in the previous holes.

The method can be used for more holes in the case of channels than for joists because of the smaller taper of the flanges. But in order to avoid using too great a number of passes X should be shortened by 10 per cent when calculating a closed hole from an open one.

There are two other methods of rolling channels. The "bending up" method, and a combination of bending up and counter flange. Fig. 16 which has been copied from the "Blast Furnace and Steel Plant" of June, 1918, gives a very clear comparison of these methods. The bending up method requires much less power than the counter flanges, and the wear on the rolls is less. On the other hand fewer passes can be laid out on a given roll length because of their increased width. This, however, is not so bad as may appear at first sight, because there is no need for enormously strong collars. A compromise is effected by the combination method.

We now come to the arrangement of the holes with regard to the rolling or pitch line. I regret that I have no time to discuss the interesting arguments of Schaefer and Tafel on this particular section of the roll turners' problem. Instructive as they are, they are put quite in the shade by Puppe's article in Stahl and Eisen (27th October, 1909) from which the following is condensed. To avoid confusion a few definitions are necessary.

The "pitch line" is a line parallel to, and half way between, the axis of the top and bottom rolls.

The "rolling line" is a base line parallel to, and immediately above or below the pitch line. It forms the basis on which to arrange the holes.

If the rolling line is below the pitch line the distance between them is called the "Overdraught," and the top roll is, therefore, larger than the bottom one.

If the rolling is above the pitch line, this distance is called underdraught and the bottom roll is the larger. As I have already mentioned, cogging rolls often come under this class.

It is the custom, in this country at any rate, to use overdraught for almost all sections. The idea is to prevent any chance of the bar lifting into the air, and to force it definitely against the lower guides, which can be more firmly fixed than the top ones. This object is very desirable, but there are other factors to be taken into account in attaining it. We have to consider the position of the center of gravity of the section as well as what I may term the "center of grip."

For thin flats where there is very little friction between the sides of the flat and the roll collar extremely little "overdraught" is sufficient.

Fig. 17 shows the effect of ¼-in. overdraught on a ½-in. flat rolled in a 36-in. mill. The flat tends to curve, as shown by the dotted line (which is drawn to scale). The end of the flat is caught on the stripper and slides forward setting up a bending moment which tends to straighten it. As the end advances, this bending moment increases until it exceeds the resistance of the flat. When this point is reached the flat gives way until a fresh contact is made with the stripper. This process repeats itself, and the result is a wavy bar.

The question of over or underdraught for channels and joists is not so simple. In these it often takes a very considerable force to release the flanges from their holes, and this must be allowed for.

The first two figures show a joist and a channel which will obviously tend to stick to the bottom roll. If the usual overdraught were given, this tendency would be increased and the result would be an enormous pressure on the stripper. To counteract this effect the bottom roll draught can be given without fear of the bar coming upwards. Similar reasoning also applies to T bars.

The use of under or overdraught in rolling flanged sections sometimes has a peculiar effect on the mill. The larger roll has a tendency to give the smaller one a higher speed of revolution. If the friction between the bar and the rolls is sufficient, the larger roll will drive the smaller. When the bar leaves the mill, the smaller roll will stop until the backlash in its couplings is taken up and its spindle can resume its drive. This causes the heavy knock which is sometimes heard just as the bar leaves the rolls.

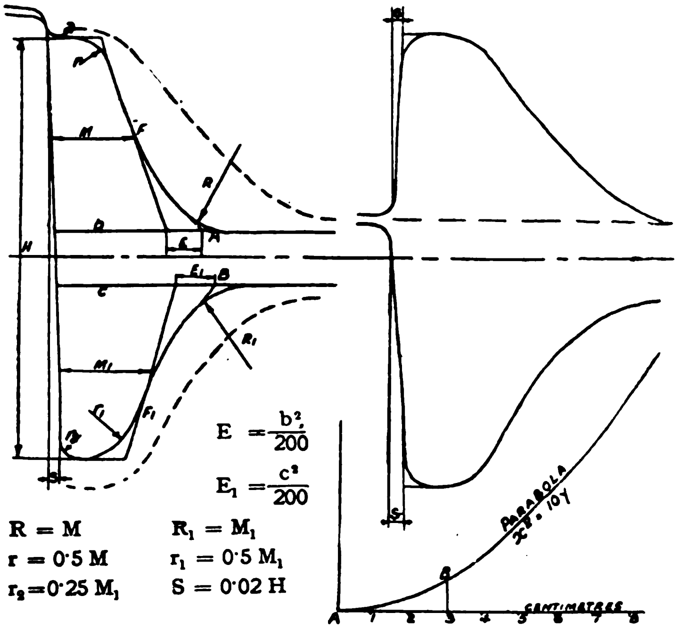


Fig. 15—Fillets and tapers for joint passes (Kirchberg).

The foregoing is very far from an exhaustive treatment of the subject. It is only a summary of the information I have collected from various sources. My object in presenting it has already been stated at the beginning. In closing, I have just one suggestion to make, and that is that practical roll turners should combine with theoretical men in order to obtain the best possible results, or better still, the practical man should be fully instructed in the theories governing this work. It is said that an ounce of practice is worth a pound of theory, but I think that the two combined together are worth a ton of either.

WILL BUILD NEW BLAST FURNACE.

Investigations which tend to show that iron ore exists in commercial quantities in this State are the background for the building of a blast furnace and steel plant at Tekoa, Wash., in the eastern part of the State, according to W. C. Hayward, president of the Commerce Steel Corporation, who declares that iron ores in the vicinity of Tekoa are equal to the Lake Superior ores. Mr. Hayward explains that only hematite ores so far have been found in this territory. He announces that his corporation will start construction immediately on a 75-ton capacity furnace.

Announcement here by transcontinental traffic officials of a proposed reduction of export steel rates contingent upon the assent of Eastern originating and intermediary carriers is expected, if ratified, to increase steel exports from the Pittsburgh and Colorado districts to the Orient through the Port of Puget Sound.

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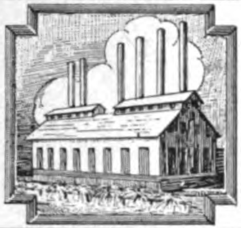
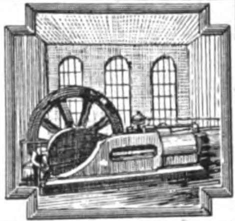


STEAM POWER DEPARTMENT



The Use of Medium Grade Gases in the Steel Industry

The Author Shows That Natural Gas, Even With Its High Heating Value, Is Not the Best Available Gas to Use in Steel Plant Heating.

By F. J. DENK

THE fuel gases principally used in the steel industry have been, up to the present time, either high grade gases, like natural gas, or low grade gases, like producer gas or blast furnace gas. Of the medium grade gases only coke oven gas has been used here and there and not as extensively as it should have been used.

It is the general belief, that natural gas, on account of its high heating value, is the best gas available. This belief, however, is erroneous. The efficiency of a gas does not depend upon its heating value, but it depends upon the flame temperature, the amount of air required for combustion, the specific heat of the waste gases and their quantity. These are the reasons, that the medium grade gases, i. e., gases with a lower heating value between about 350 and 500 Btu/cu. ft. are more efficient in a furnace, than the natural gas with a heating value of around 1,000 Btu/cu. ft. The accompanying table gives the heating values and the corresponding theoretical flame temperatures for the different gases in question.

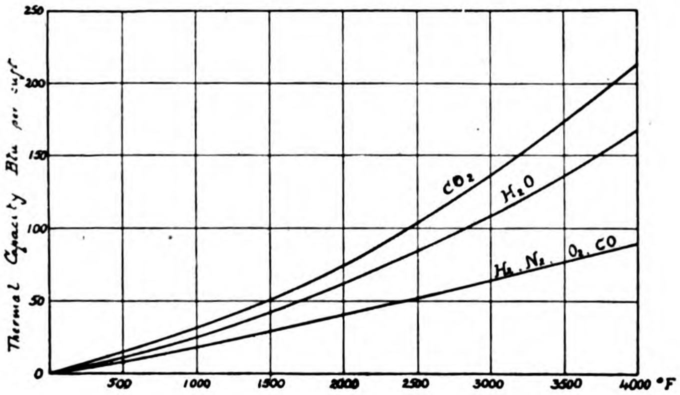


Fig. 1.

Gas.	Lower Heating Value.	Air Required.	Theoretical Flame Temperature.
Natural Gas	1018 Btu/cu.ft.	10.64 cu.ft.	3226 deg. F.
Carbon Water Gas	533 "	4.89 "	3422 deg. F.
Coke Oven Gas	425 "	4.06 "	3302 deg. F.
Elliott Gas	382 "	3.39 "	3400 deg. F.
Producer Gas	130 "	1.10 "	2673 deg. F.
Blast Furnace Gas	93 "	.70 "	2323 deg. F.

All gases to be considered cold and burned with the theoretically required minimum amount of air.

The table shows, that the quantity of air increases with the heating value. The higher the latter, the more air is required. But the increase in heating value is due to the increase in hydrocarbons. These hydrocarbons burn to carbon dioxide and water vapor, which are those two constituents of the waste gases, which have the highest specific heats. Besides, these specific heats increase rapidly with increasing temperature, whereas the specific heats for nitrogen, oxygen and air increase slowly. (See Fig. 1.) Water vapor and carbon dioxide absorb, therefore, under otherwise equal conditions, much larger quantities of heat, than nitrogen and oxygen or air and this is the reason for the

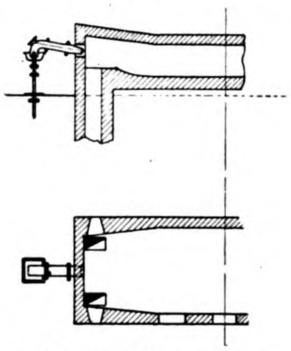


Fig. 2—30-ton O. H. furnace changed for medium grade gas.

lower flame temperature of those gases, which, like natural gas, are composed almost entirely of hydrocarbons, because they form, when burning, carbon dioxide and water vapor.

Elliott gas is a combination coal and water gas and may, for this reason, be named "Duo" gas. The main advantage in its manufacture is to be seen in the fact, that the volatile matter and the tarry vapors, driven off of the green coal right after charging, is burned into fixed gases, thus avoiding the necessity of adding oil to enrich the gas. So far it has been used and proven its value in the glass industry, but steps have been taken, to introduce it in the steel industry, where it will be found to be as efficient as coke oven gas.

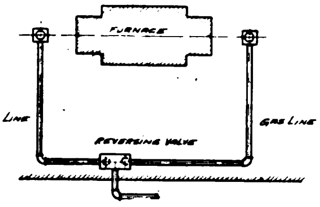


Fig. 3—General arrangement of gas piping to 30-ton O. H. furnace.

Actual tests have shown that the amount of gas made from one short ton of coal varied between 57,000 and 63,000 cu. ft. with a corresponding high heating value of 465 and 415 Btu/cu. ft. This gas takes, therefore, the place of coke oven gas, where there is not enough of the latter to supply all the needs of the steel plant, or where there is no coke oven plant at all. The maximum amount of gas obtainable from a coke oven plant is around 10,000 cu. ft., 1 ton of coal with about the same high heating value as Elliott gas.

This quantity, however, is obtainable only in a plant, where the heating of the ovens is done by means of producer gas or blast furnace gas. Wherever coke oven gas is used for this purpose, the above given amount will be reduced to about 6,000 cu. ft. per ton of coal. Now, there is no doubt, that it is of advantage for a blast furnace plant, to make its own coke, which will be cheaper than buying it outside, because the resulting gas can be charged to the steel plant. But 6,000 cu. ft. or even 10,000 cu. ft. per ton do not go very far and the conditions may become such, that the coke oven plant furnishes enough coke for the blast furnaces, but not enough gas for the steel plant. In this case an installation of Elliott producers will fill the needed want to perfection, because it furnishes a gas of more equal quality than coke oven gas, but it takes less space than a coke oven plant.

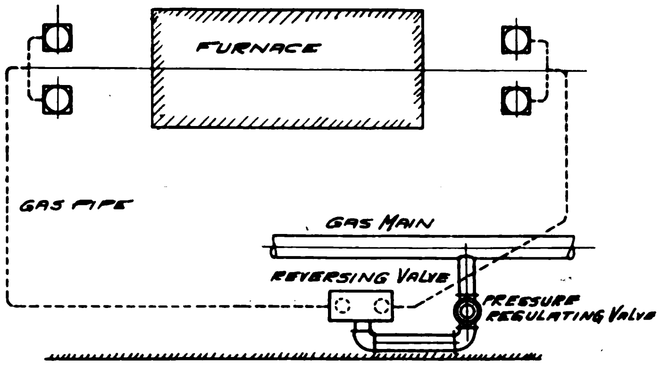


Fig. 4—General arrangement of piping for 100-ton O. H. furnace.

In the following some data will be given, showing the saving made when using coke oven gas over producer gas and a few sketches will illustrate the arrangement required for the use of coke oven gas on O. H. furnaces. Everything that is said below in connection with coke oven gas holds, for the reasons given above, also good for Elliott gas, the latter having the same heating value and the same specific weight.

Comparative tests on open hearth furnaces, fired with producer gas with 143 Btu/cu. ft. and with a coke oven gas having 408 Btu/cu. ft. showed the following results: With producer gas one long ton of steel required 661.5 lbs. of coal, whereas 11.477 cu. ft. of coke oven gas produced the same result. Assuming a producer efficiency of 89 per cent, the heat equivalent of the two fuels for one long ton of steel was 1414 Btu in the form of producer gas against 1,000 Btu in the form of coke oven gas. Besides, with the coke oven gas the daily output was 49 tons, with the producer gas only 39 tons.

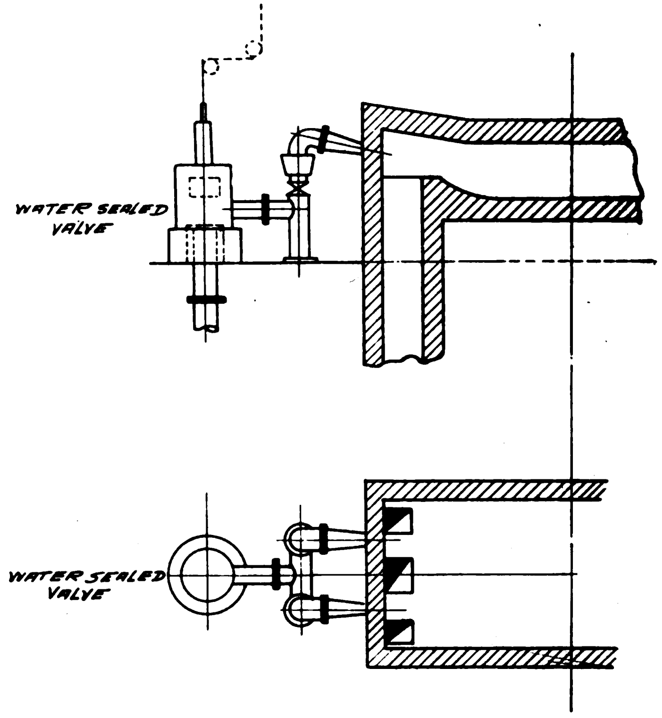


Fig. 5—Improved piping for 100-ton O. H. furnace.

In a 30 T open hearth furnace run with producer gas, the average length of the journey was 2½ months, giving 8,016 long tons of steel. The same furnace, run with coke oven gas had an average life of 3½ months, giving 10,725 long tons of steel. The coke oven gas fired furnace gave, therefore, 100 heats—2,700 tons more than the producer gas fired furnace.

In a 100 T open hearth furnace, the tonnage obtained in a charge was 96.5 tons, when fired with producer gas, against 97.3 tons when fired with coke oven gas.

In a 12 T open hearth furnace the daily production was 48 tons when running on coke oven gas against 39 tons, when running on producer gas, which is an increase of 23 per cent in favor of the coke oven gas. The average consumption of the latter was 9,888 cu. ft. long ton.

The main advantages in the application of coke oven gas or its equivalent may be found in the following.

1. Increase in production.
2. Simplification in the construction of the furnace, because the gas regenerating chambers can be omitted, the gas entering the furnace by means of ordinary burners.
3. Decrease in the cost for repairs.
4. Lower first cost and operating cost.
5. Easy working of the charge.

A formula for calculating the relative value of the different gases has been given by E. H. Steck.* It reads:

$$V_t = V_g \frac{T_t - T_r}{T_g - T_r} \times \frac{C_t}{C_g},$$

where

V_t the relative value of the new gas (coke oven or Elliott gas).
V_g the relative value of producer gas.
T_r the temperature in the furnace.
T_t the flame temperature of the new gas.
T_g the flame temperature of the producer gas.
C_t the Btu per cu. ft. of waste gases of the new gas.
C_g the Btu per cu. ft. of waste gases of the producer gas.

For instance, when a comparison is wanted of the relative value of using cold coke oven gas and cold air, against producer gas and air preheated to 1,000 deg. F., we have the following, when $T_r = 2{,}800$, $T_t = 3{,}300$, $T_g = 3{,}000$, $C_t = 106$ and $C_g = 143$.

$$V_t = V_g \frac{3{,}300 - 2{,}800}{3{,}000 - 2{,}800} \times \frac{106}{143} = 1.85\ V_g$$

for Elliott gas with $T_t = 3{,}400$ deg. F. we have

$$V_t = 2.21\ V_g.$$

This shows, that as long as the cost of coke oven gas is less than 1.85 times, and that of Elliott gas less than 2.21 times as high as that of producer gas, the two gases work more economical than the latter.

The use of the medium grade gases is not restricted to open hearth furnaces. They may be used in heating furnaces, mixers, sheet and pair furnaces, annealing furnaces, galvanizing pots, etc. In fact, for the last three types, Elliott gas is the most ideal fuel—coke oven gas being out of the question for obvious reasons—giving a clean gas of uniform composition, temperature and pressure.

Fig. 2 shows section and plan of a 30 T open hearth furnace; Fig. 3 illustrates the arrangement of the gas pipes, burners and the reversing valve for the same furnace. Fig. 4 shows the gas piping, burners and reversing valve for a 100 T open hearth furnace.

With this arrangement explosions frequently occurred in the lines on the waste gas side, due to the remaining of some unburned gas in these lines, which formed explosive mixtures with the furnace atmosphere. The same happened when during shut-downs gas entered through leaking valves. This trouble was prevented by installing another water-sealed valve on each head of the furnace close to the burners as illustrated in Fig. 5.

It is needless to say, that every furnace, which has been operated with a low grade or a high grade gas, must be changed to suit conditions, when it is to be operated with a medium grade gas. This is a point, which is often overlooked. When, then, the furnace is not working properly and does not give the expected results, the blame is invariably laid to the new fuel but not, where it should be laid, i. e., to the furnace.

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*The application of blast furnace gas and coke oven gas in the steel industry. Fenerungstecknik, Vol. 11, Number 5.

MECHANICAL ENGINEERS MEET.

Announcing that a 5-day annual meeting will be held in New York, December 5 to 9, the American Society of Mechanical Engineers has made public a statement by Herbert Hoover saying that the investigation of industrial waste recently completed by the American Engineering Council of the Federated American Engineering Societies has paved the way for an advance in American industry. The findings of this council's Committee on Elimination of Waste in Industry will form the leading topic of discussion.

Conditions in five basic industries "assayed"—to use Mr. Hoover's description—by the committee will be discussed December 5. The industries include the metal trades, printing, boots and shoes, clothing and building. In the evening will come a session on education and training in the industries.

On December 6 simultaneous sessions on railroads, power, and machine shop practice will be held. Speakers at the machine shop session will include Prof. John Airey, University of Michigan, who will discuss "The Art of Milling," and J. A. Smith, General Electric Co., and J. J. Callahan, Worcester, Mass., who will speak on "Waste in Machine Industry."

Sessions of the fuel and material handling divisions and of the student branches of the society will be held December 8. In the afternoon a joint session with the Society for the Promotion of Engineering Education will be held, on "Professional Engineering Education for the Industries." Speakers will be F. C. Pratt, vice-president General Electric Co. and president Yale Engineering Society; J. E. Otterson, president Winchester Repeating Arms Co., New Haven; Dexter S. Kimball, president-elect of the society, vice-president American Engineering Council and dean of engineering at Cornell; and Prof. A. G. Christie, Johns Hopkins. On December 9 sessions of the textile, ordnance and aeronautic sections will be held. The ordnance sessions will take up the recent army demonstrations at Aberdeen, Md., where the mechanical engineers cooperated.

NEW YORK ELECTRO CHEMISTS HOLD A MEETING IN MEMORY OF DR. J. W. RICHARDS.

A meeting of the New York section of the American Electrochemical Society was held Wednesday evening, November 16, at Rumford Hall, 52 East Forty-first Street, New York, at which several addresses were delivered on the life and works of the late Dr. Joseph W. Richards. Dr. Carl Hering, consulting electrical engineer, Philadelphia, reviewed the work of Doctor Richards as president and secretary of the American Electrochemical Society; Dr. W. S. Landis, president American Cyanamid Co., New York, took as his theme, "Dr. Richards as a Teacher at Lehigh University," while H. C. Parmele, editor "Chemical and Metallurgical Engineering," reviewed Ooctor Dichards' work as an editor and author. These memorial addresses were followed by one by Dr. Frederick G. Cottrell on "Personal Observations on the Russian Situation."

Successful Ash Conveying System

New Plant as Installed at the Works of the Sweet Steel Company of Williamsport, Pa., Is Giving Very Good Success—Useful to Plants Having Boilers or Gas Producers

By CHARLES LONGENECKER

THE economical disposition of ashes from gas producers or boiler furnaces is, at many plants, a serious problem. Some plants are so fortunately located that the problem is readily solved, but this is not the case with the majority. In most cases there are limitations imposed which in themselves determine the type of equipment permissible, while again the cost of equipment may preclude certain systems. The latter is very frequently the controlling feature. To those engineers confronted with such limitations as those mentioned, a description of the ash conveying system installed at the plant of the Sweet Steel Company at Williamsport, Pa., may be of interest. The simplicity of the device as a unit and its low first cost will appeal to those who are limited in space for such an installation as well as limited in means for the purchase of additional equipment.

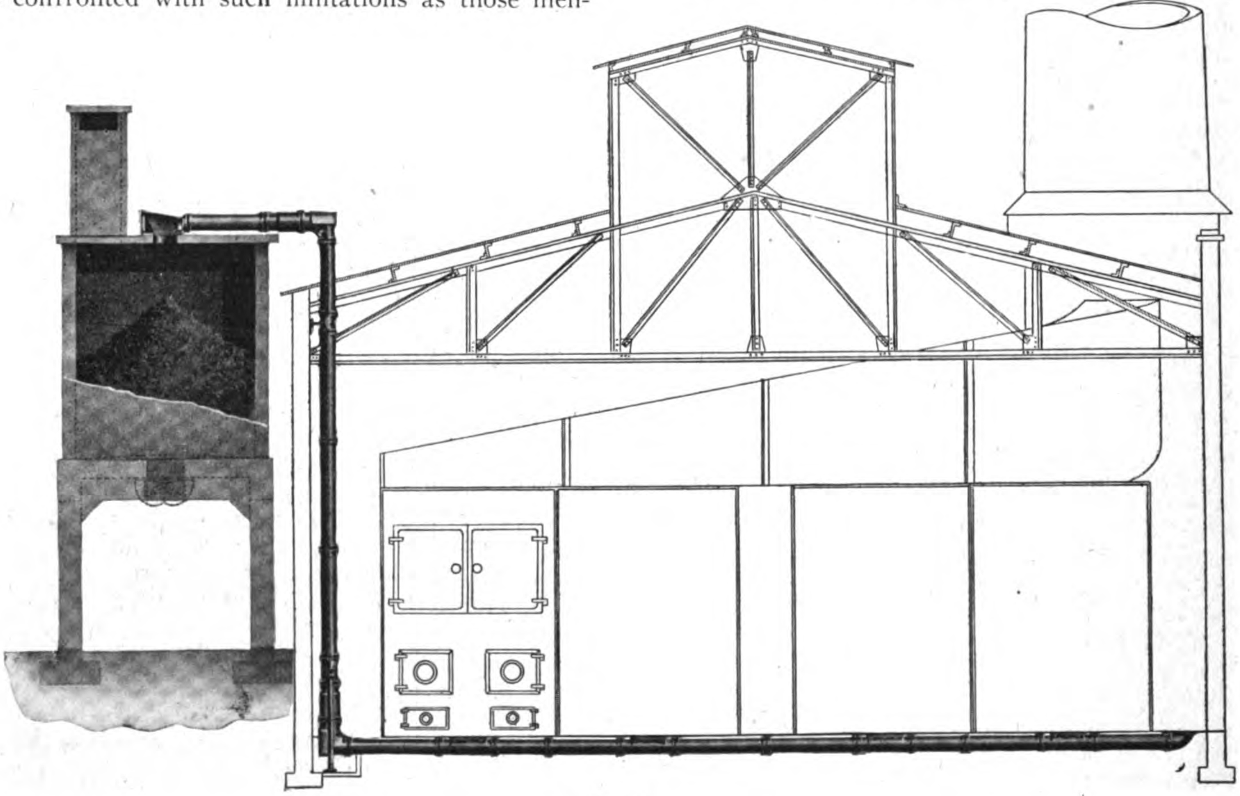

Fig. 1.

The system referred to is illustrated in Fig. 1 as applied to gas producers and boilers. For the sake of illustration the general scheme as applied to boilers is to be preferred. The motive power is steam, which forms a suction of air from the air inlet to the steam jet and from the jet propels of its own force. In this illustration the opening into the conveyor pipe is seen in close proximity to the producer or furnace. The details of this opening can be better understood by reference to the small insert and marked as detail "A." At the entrance there is a plate termed the anvil plate upon which are placed any clinkers which are too large to drop into the pipe. When a clinker is placed on this plate and struck a sharp blow it is broken into pieces which, dropping into the pipe, are at once carried away. At the point "D" in the general layout is the 90-degree steam unit. This is one of the most important features of the whole system and on it depends the success of the installation, both physically and economically.

The vital points in connection with this 90-degree steam unit are the location of the steam nozzle and the construction of same. The axis of this nozzle must be in perfect alignment with the axis of the pipe into which the steam is blown. Should the alignment be otherwise than perfect the wear on the pipe lining will be too severe and costly erosion be the result. This alignment is assured by means of an accurately tapped gray iron insert into which the nozzle bushing screws. In the early conveyors the steam nozzles were made of bronze, but after some time it was found that these would not preserve their original form, but that the steam would cut out the metal with the result that more steam was consumed than was necessary for the work. Many experiments were tried to remedy this defect until finally monel metal was found to possess the qualities desired and nozzles cast of this metal have given the best of satisfaction. The nozzle is so constructed that it can easily be removed and another inserted with only a few minutes delay.

Next to importance to the steam nozzle in construction is the pipe through which the ash passes. The abrasiveness of ash is known to all, but some ash possesses this quality to a greater degree than others. Naturally, the rapid passage of this material through the pipe causes a certain cutting of those parts in contact with the ash, but at certain points this cutting action is more severe than at others. The point of wear is found where the pipe makes the 90-degree turn and just above the steam nozzle. The construction of the pipe at this point and at all other bends is ingenious.

In the illustration will be noticed the additional lining which is made in small sections about 7 inches long and cast from a special brake shoe insert metal which is exceedingly hard. This lining extends about four feet above the nozzle and is rapidly interchangeable. The doors giving access to the lining are secured by steel spring bars and are in no case bolted. It has been found that bolts have a tendency to rust and when rusted are difficult to remove. Where the spring bars are used it requires only the tap of a hammer and the door opens. These liners will not need replacing until some 5,000 tons of ash have passed over them and are furnished at all bends in the line from 45 degrees to 135 degrees.

In case of heavy tonnage protection is also afforded the bottom of the suction line as here there is a certain amount of erosion. The liners extending along the bottom are cast in sections varying from 18 in. to 24 in. —thus it is a very simple matter to renew these through the intake openings.

The pipe itself is about 1 in. in thickness, 8 in. inside diameter and will weigh approximately 100 pounds per linear foot. This pipe is not machineable, as it is composed of a special iron known as "carbo-iron," which is a white iron of extreme hardness.

One other point presented an opportunity for ingenious construction. This is the last section of the pipe where the ash is discharged from the system. The difficulty which arose here was that the ash leaving the pipe at a high velocity cut into any obstacle which was installed to take the impact. The solution was the building of a special casting known as the "ash cushioning deflector box." This is seen in the illustration at the discharge end and is marked "B." The casting is so formed that a cushion of ash collects in a space which forms a pocket. The ash leaving the pipes strikes this cushion and drops into the receptacle provided for its collection. Where it is possible to discharge the ash into any open outdoor space to be filled there is no necessity for this ash deflector. This is the case at one steel plant where the ashes are used to fill a swamp depression. Here the length of the line from the boiler room to the disposal point is 195 feet.

In operation this method of ash disposal will consume approximately 350 pounds of steam per ton of ash removed. This quantity will vary with the steam pressure and with the length of the line. The capacity of the installation at the plant in question is from six to eight tons of ash per hour. The ash is removed at such a time as is most convenient with regard to the operation of the steel plant. Usually it is most desirable to discharge the ash at noon when the demand for steam is not so pressing and when in many in-

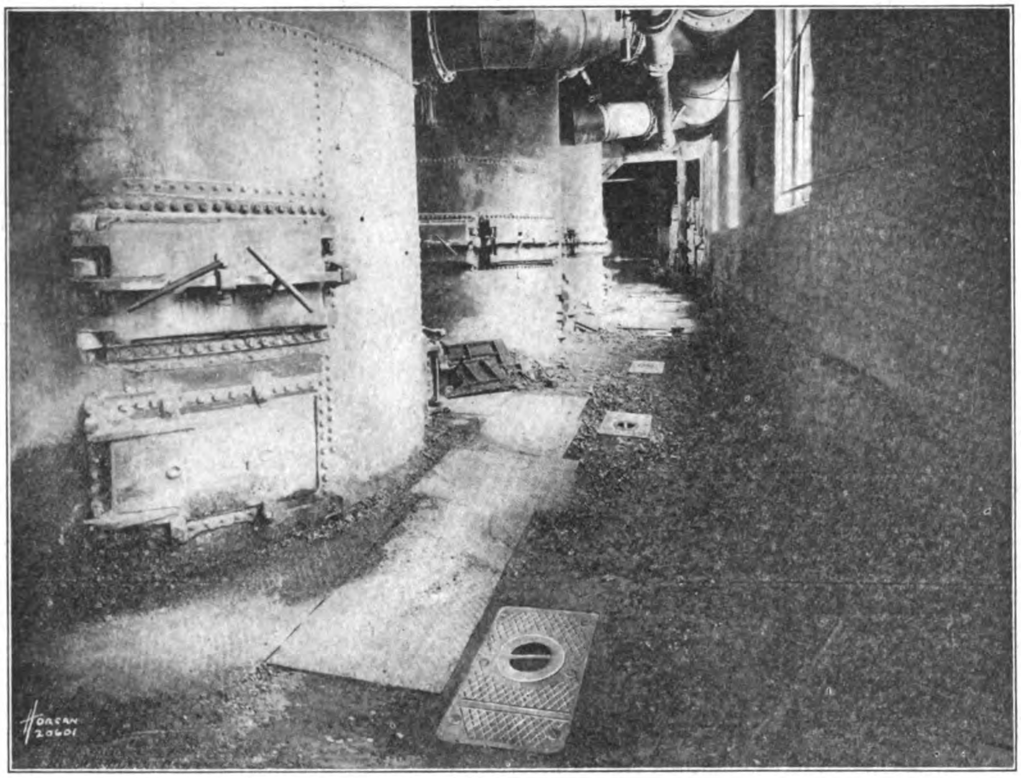

Fig. 2—Plant installed at the Hyde Park Gas Company, Scranton, Pa.

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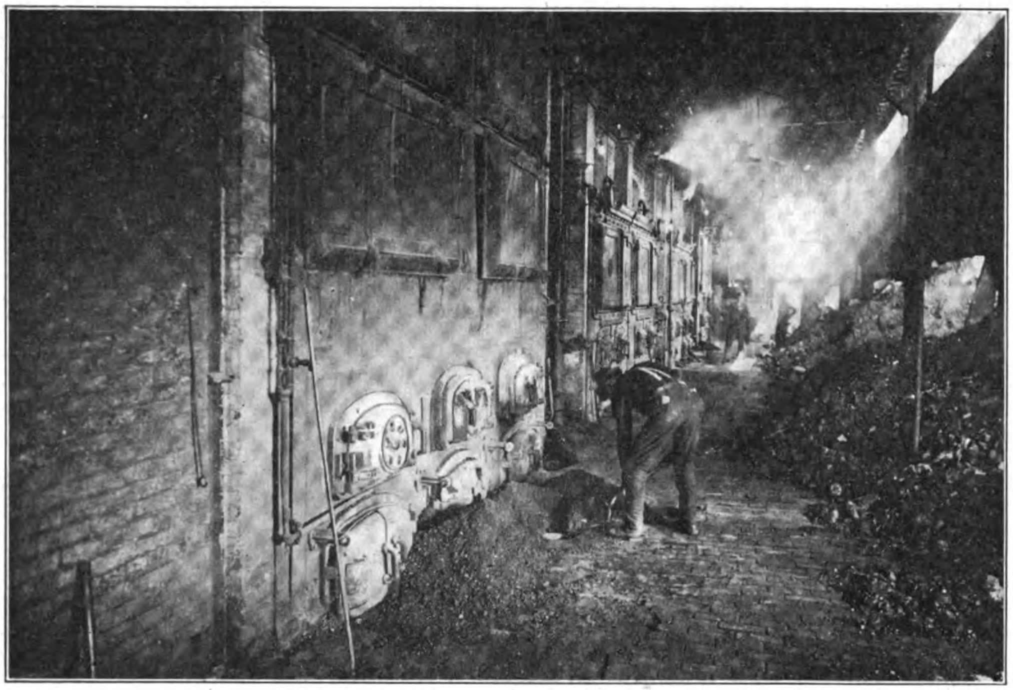


Fig. 3—Plant Installed in Sweet Steel Company, Williamsport, Pa.

stances the steam can be used with practically no cost. Instead of letting the steam blow off into the air, which it will do when there is no demand, it is employed for the more useful purpose cited.

The maintenance cost will not exceed 2½ cents per ton of ash unless there is some unusual condition, but the condition must be most unusual to be higher than this figure.

Besides the savings in operation which will accrue, there is the elimination of dust which is the case where ash is handled by hand or in machinery which agitates it. The labor question is at once solved as there is no extra labor required.

The system here described was installed by the Girtanner Engineering Corporation of New York. This company has standardized the parts entering into the construction and this has further simplified the complete installation.

METAL COATINGS FOR IRON.

A series of tests on the durability of metallic coatings, applied to iron to prevent rusting, were conducted by Dr. W. Lange, of Berlin, on behalf of the War Office during the war, and the results of the tests were published in the April and June issues of the "Zeitschrift fur Metallkunde." The protective metals tested were zinc, lead, tin, aluminum, and the tests were made on foils or wires, in water (distilled or tap water), in diluted solutions of common salt or sea water, and in the open air, sometimes saturated with moisture and carbon dioxide. In the case of zinc various electrolytic baths were used, and also the nigrosin treatment of Langbein-Pfanhauser, in which a film of black nickel is finally deposited by electrolysis on the coating which is subsequently greased with vaseline; the good results obtained may partly be due to the vaseline. Electrolytic zinc coatings failed in many cases because they were of insufficient thickness. Dipping into fused zinc avoids this trouble; sherardizing answered nearly as well as this last process, although the coatings were not of uniform thickness; spraying after Schoop was also fairly satisfactory, except in distilled water—which is far more destructive to all zinc coatings than tap water—and in salt solution. Of the electrolytic lead baths those of Betts (hydro silico-fluoric acid) and of Schlotter (phenolsulphonic acid) answered best; distilled water again proved more destructive than tap water and salt solution. When lead is to be sprayed on, a film of zinc or tin should first be applied to the iron by spraying in order to secure adhesion. In the case of tin, alkaline baths, a solution of the double tin ammonium chloride and the Schlotter acid were tried; the last-mentioned bath answered best. A steel tube dipped into molten tin, rusted in three weeks when heated by steam during the day and kept cold at night. Very good results were obtained with aluminum-spraying. Some new secret processes did not pass the tests at all satisfactorily.

ALLOY WORK DISCUSSED.

The work on alloys being done by the Bureau of Mines was reviewed at a meeting between bureau officials and the standing committee of the American Institute of Metals. It was decided that the standing committee would meet twice a year in the future at the Bureau of Mines. Those in attendance at the meeting were: H. Foster Bain, director, Bureau of Mines; W. M. Corse, Monel Metal Products Corp.: R. B. Moore, chief chemist, Bureau of Mines; William B. Price, Scovill Manufacturing Co.; W. H. Bassett, American Brass Co.; R. J. Anderson, Bureau of Mines; L. W. Olson, Ohio Brass Co.; C. H. Bierbaum. Lumen Bearing Co.; George C. Stone, New Jersey Zinc Co.; W. R. Webster, Bridgeport Brass Co.: H. W. Gillett, Bureau of Mines: DeCourcy Browne; Paul D. Merica, International Nickel Co.; J. L. Jones, Westinghouse Electric & Manufacturing Co.; John F. Thompson, International Nickel Co.; William A. Cowan, National Lead Co.; Andrew Stewart, Bureau of Mines; Dorsey A. Lyon, Bureau of Mines; E. L. Mack, Bureau of Mines.

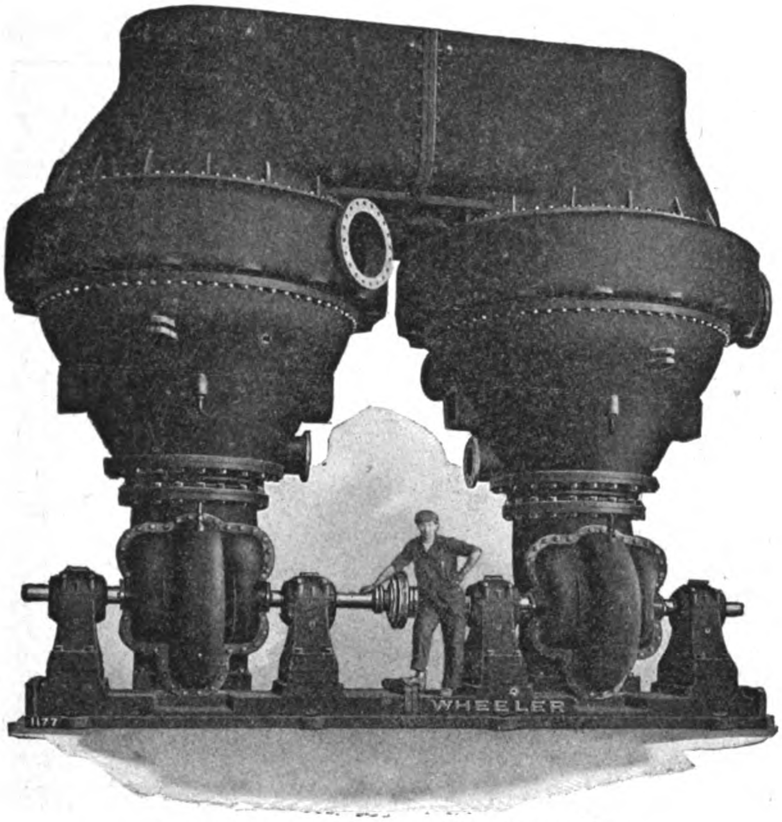
WITH THE EQUIPMENT MANUFACTURERS

A TWIN-JET CONDENSER FOR 20,000-KW TURBINE

Herewith is illustrated the latest large jet condenser unit manufactured by the Wheeler Condenser & Engineering Company, Carteret, N. J., which is of special interest on account of its size and the operation of auxiliaries. It was built to serve a 20,000-kw General Electric turbine at Hauto, Pa., plant of the Pennsylvania Power & Light Company. Designed for 28-in. vacuum with 75-deg. injection water, it will handle a total of 25,000 gpm. or 12,500 gpm for each removal pump.

Twin jet condensers are frequently furnished for serving large units because they have greater flexibility, are easier to handle, and reduce the headroom. Each condenser body, as shown, is mounted over a separate removal pump, and will also be provided with separate air pumps, so in times of light load or with cold injection water, only one-half of the unit need be operated, resulting in a saving of 50 per cent of the normal power. When in full operation, the water levels in the two bodies are equalized by means of a connecting pipe, flanges for which are the two lower ones shown on the condenser bodies opposite each other.

Both a geared turbine and motor are furnished to drive the removal pumps of this unit—each being large enough to drive both pumps alone—so that the load can be divided as required to maintain the heat balance of the plant by producing more or less exhaust steam, as can be utilized economically for heating feed water. These are not shown in the photograph, as they were sent direct to the plant and could not be assembled in the shop where the photograph was taken. A feature of the pump drive is a magnetic clutch, which unites the shafts between the inside shaft bearings. It permits either pump to be driven independently of the other, without interfering with continuous operation, when only one half of the condenser is to be operated.



Large jet condenser for 20,000-kw turbine.

As will be noted from the photograph, an expansion joint is provided between each condenser body and its removal pump. By this arrangement, the condenser body is suspended from the turbine nozzle, while the removal pump and its driver are mounted upon a rigid foundation, the expansion joint absorbing temperature strains. An expansion joint provided in this way eliminates the large expansion joints usually placed between the turbine and the condenser.

Another point of interest is the vertically split casing of the horizontal double suction tail water pump serving each condenser. When it is necessary to inspect or repair the rotor or any of the wearing parts, it is simply a matter of removing the bolts, and uncoupling the rotor. Before this design was developed, considerable time and effort were required to get at and remove the rotor.

This huge condensing unit will be served by two large Wheeler steam jet air pumps of the combined surface intercondenser and heater type, and two turbo air pumps, each pump being large enough for one condenser. Boiler feed make-up is circulater to the intercondenser and heater of each steam jet air pump.

STEEL PICKLING COMPOUND

The Hoffman Process Company of Pittsburgh, Pa., has developed an organic compound to improve the practice of pickling steel, iron and copper.

This compound is perfectly soluble and is used in what might be called a trace, since one pint at two hour intervals suffices for a tank containing 1,000 to 1,500 of pickling solution.

It has two effects, the first, through an increase of surface tension, is to produce a foam which acts as a filter, preventing the escape of noxious acid vapors, which damage buildings, machinery and injure the health of workmen.

The second effect is described by the U. S. Bureau of Mines as inhibitive and is regarded as the most important, although less noticeable.

The solution is no longer one of acid and water, but one of acid and water plus an organic compound whose action is quite different since it reduces the action of the acid on the metal and directs it to the solution of scale. The result is a saving of 15 to 20 per cent of the acid usually required to clean the metal; a saving of the metal which would be otherwise destroyed by this excess of acid and a smoother surface which, if galvanized, requires less spelter to coat.

As an example, an extended test in a wire mill using 30 tons of 66-deg. sulphuric acid showed a saving of five tons of acid daily and two and one-half tons of metal through the use of five gallons of this compound. Another customer reported a saving of 22 per cent of his acid and a reduction of his galvanizing cost of 15 per cent.

NEWS OF THE PLANTS

The Hancock Steel Company, Martinsburg, W. Va., has completed plans and will call for bids at an early date for the construction of its proposed new plant at Brosius, W. Va., near Hancock, Md.; with initial main building to be one-story 130x 200 feet. A number of other buildings will also be erected. The new plant is estimated to cost in excess of $500,000. The company has recently increased its capital to $3,000,000, to carry out the details of the project. F. Vernon Aler, Martinsburg, heads the organization. Ernest McGeorge, 1900 Euclid Building, Cleveland, Ohio, is engineer.

The Bethlehem Steel Company, Bethlehem, Pa., has recently resumed operations at its Furnace D, making two units now in blast at the plant. The furnace was banked last April. Blast Furnace G at mill is being relined. At its Steelton, Pa., works, the company has resumed production at the 24-in. rolling mill, which has been idle for some weeks past.

The New England Steel Castings Company, East Longmeadow, Mass., has called for bids for the rebuilding of its local plant, recently destroyed by fire, with loss aggregating close to $75,000. The new structure will be one-story, 68x122 feet, brick and steel. Morris W. Maloney, 145 Chestnut Street, Springfield, Mass., is architect for the work.

In connection with its entry into the rail manufacturing industry, the Inland Steel Company, Block Avenue, Indiana Harbor, Ind., is planning for the conversion of its local structural steel mill into a plant for the manufacture of steel rails. It is proposed to install the necessary machinery to provide for an output of about 2,000 tons of material per day. Present schedule calls for operation early in March. The executive offices of the company are at 388 Dearborn Street, Chicago, Ill.

The American Steel & Wire Company, 94 Grove Street, Worcester, Mass., is pushing construction on the new plant addition to its South Works, and plans for early occupancy for general increase in production. It will be three-story, 120x145 feet, and is estimated to cost approximately $150,000. C. E. Goodrich is company engineer.

The Kansas City Spiral Pipe Company, 416 Dwight Building, Kansas City, Mo., has acquired property at Leeds, Mo., for the erection of a new plant for the manufacture of riveted steel pipe. Plans are under way for the initial works, to comprise a one-story brick and steel building, 60x300 feet. E. J. Gordon is secretary of the company.

The Rochester Rolling Mills, Rochester, N. Y., have been organized under state laws to operate a local iron and steel works. The company is headed by F. Christman, J. Noraconk and J. H. Farrell, Rochester. It is represented by F. I. Stoker, attorney, Rochester.

The McKinney Steel Company, Cleveland, Ohio, has plans nearing completion for a new sintering plant at its works to have a daily capacity of approximately 350 tons. It is proposed to inaugurate construction early in the coming year.

The Carnegie Steel Company, New Castle, Pa., has placed another furnace in blast at its local plant, increasing production to a point about 75 per cent of plant capacity.

The Chester Iron & Foundry Company, 7800 Vulcan Street, St. Louis, Mo., has completed plans for the erection of an addition to its plant for increased capacity, to be 45x115 feet, and estimated to cost about $42,000. L. Haeger, 3824 Utah Street, St. Louis, is architect. A. J. Schaelich is president of the company in charge.

The Charleroi Iron Works, Charleroi, Pa., manufacturer of structural shapes and other iron and steel products, has removed its works from the buildings on McKean Avenue, heretofore occupied, to a new site in the lower section of the city. The new buildings will provide for increased production.

The Agricola Pipe Company, Gadsden, Ala., manufacturer of iron pipe, is arranging for the rebuilding of the portion of its local plant recently destroyed by fire with loss estimated at $75,000, including machinery. Otto Agricola is president of the company.

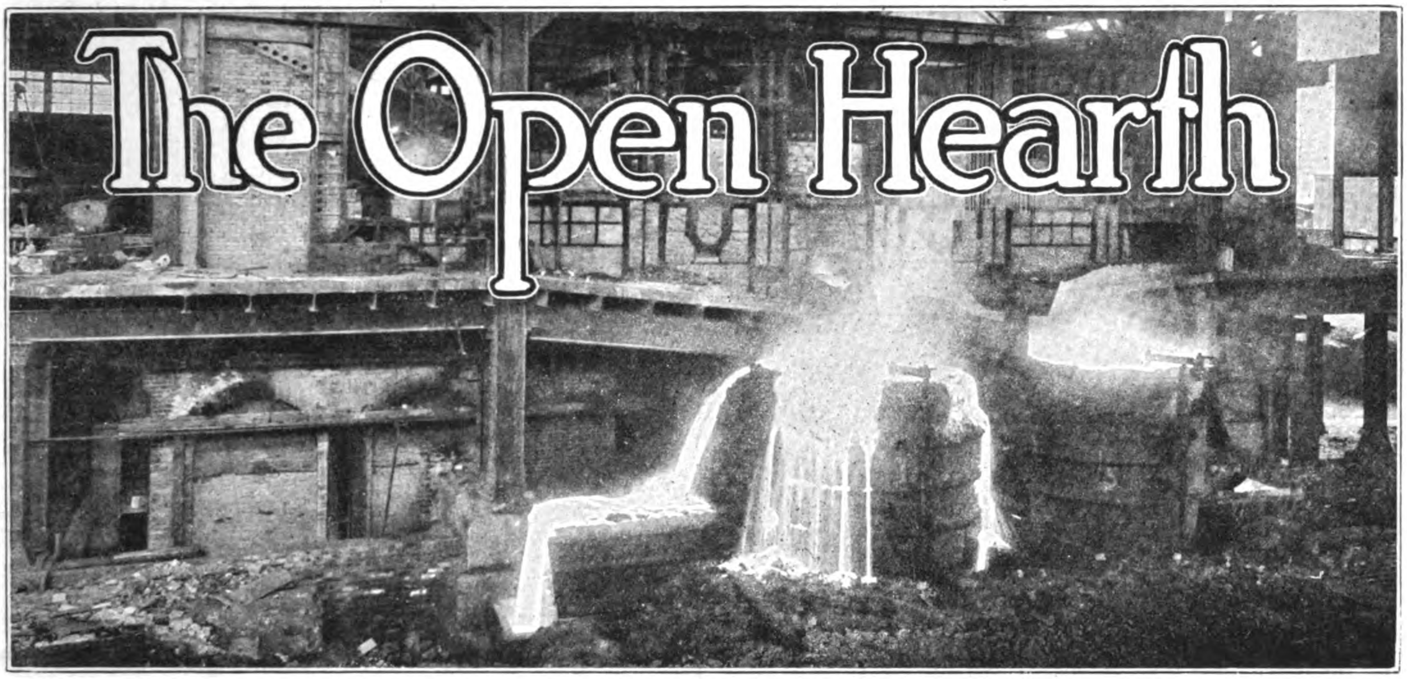
S. Cheney & Sons, Seneca Street, Manlius, N. Y., manufacturer of iron products, have plans under way for the construction of a new building at their plant, for increased production; it will be one-story, brick. Melvin L. King, Snow Building, Syracuse, N. Y., is architect for the work.

The O. J. Bloss Iron Works, 253 Monitor Street, Brooklyn, N. Y., will soon commence the erection of a new one-story plant building, to be about 30x100 feet. It will be located on Henry Street, near Norman Avenue. Charles A. P. Jehle, 350 Fulton Street, Brooklyn, is architect.

The Omaha Semi-Steel Foundry Company, 1409 Jackson Street, Omaha, Neb., operated by Bergman & Hinkens, has completed plans for the construction of a new one and two-story and part basement plant building at Eleventh and Grace Streets. It will be about 80x100 feet, and is reported to be estimated to cost close to $50,000. W. F. Gernandt, 701 O. L. & B. Association Building, Omaha, is architect.

Blast furnace operations are on the increases in the Buffalo, N. Y., district, and a number of stacks have recently been blown in. The iron and steel companies in this section are reported to be planning for early increase in present production. The Rogers, Brown Company has blown in a second furnace at its mill, and expects to keep the two units in blast. The Donner Steel Company has also placed a second stack in operation at its mill. The Lackawanna Steel Company has one blast furnace running at the present time for the production of pig iron for the general commercial market. The Buffalo-Union Furnace Company has one blast furnace in operation, as has also the Wickwire-Spencer Steel Company.

The Ellwood Ivins Tube Works, Oak Lane Station, Philadelphia, Pa., has construction well under way in connection with the rebuilding of its plant, destroyed by fire some time ago. The company specializes in the manufacture of seamless steel tubing, and four of the new buildings are now being occupied for general production. A number of other structures are nearing completion and will be placed in service at an early date. The complete plant is estimated to represent an investment in excess of $200,000. Ellwood Ivins heads the company.



The Open Hearth

T. G. Shelton of High Point, N. C., has been appointed general manager of the American Foundry Company, which recently was organized at Salisbury, N. C.

V V

Victor E. Hillman, metallurgist at the Crompton & Knowles Loom Works, Worcester, Mass., is to be the instructor of a class for the elementary instruction in treatment, manufacture and fabrication of steel, to be formed by the Worcester, Mass., chapter, American Society for Steel Treating.

V V

T. A. Jones has been elected president of the W. A. Jones Foundry & Machine Company, Chicago, Ill., to succeed William A. Jones, who died recently. Mr. T. A. Jones has been secretary and treasurer of the company for several years. W. G. Jones who has been manager, continued in that position and also has been elected vice president and treasurer. J. A. Sizer has been elected secretary. The former policy of the firm is to be carried forward without change.

V V

C. H. Hobbs has been appointed assistant general manager of sales of the Detroit Seamless Steel Tubes Company, Detroit, a newly created position. Mr. Hobbs was formerly with the Lackawanna Steel Company with which Company he served for 14 years.

V V

Edward E. Book has been appointed welfare director of the Youngstown Steel Car Company, Niles, Ohio. For several years he was in the employ of the Pittsburgh & Lake Erie Railroad at McKees Rocks, Pa.

V V

Bradley Wheeler recently resigned his position as open hearth superintendent of the Minnesota Steel Company, Duluth.

V V

William Weaver Lukens, who resigned recently as president of the Alan Wood Iron & Steel Company, Philadelphia, was presented with a silver loving cup by the employes of the main office of the company.

V V

Charles H. Chubbuck, chief engineer for the McClintic-Marshall Co., Pittsburgh, recently returned from China where he was identified with bridge and other construction work.

Howell Macduff, son of Thomas Macduff, cashier of the Worcester, Mass., district of the American Steel & Wire Company, has taken a position on the superintendent's staff at the north works of the company in that city.

V V

C. A. Dunn has resigned his position as general superintendent of the Detroit Seamless Steel Tubes Company, Detroit, to become connected with the sales department of the Prime Mfg. Company, Milwaukee.

V V

Benjamin F. Jones, Jr., president of the Jones & Laughlin Steel Company, Pittsburgh, has donated $25,000 for building of a home for the new dean of the engineering school, Princeton University, Princeton, N. J.

V V

Theodore Wagner, New Britain, Conn., who, for 37 years, was foreman of the Stanley Works and who resigned four years ago to accept a position with the Worcester Pressed Steel Co., Milford, Conn., was recently made general superintendent of John D. Crosby Co., Pawtuckett, R. I.

V V

Harry Ross Jones, president of the United Alloy Steel Corporation, Canton, Ohio, and Edward L. Hang, vice president and secretary, have resigned effective December 31st, after 18 years continuous service in the organization. Both men will continue to serve on the board of directors and Mr. Jones will remain on the executive committee of the company until the annual meeting next April. Mr. Jones, it is announced, will look after his personal interests while Mr. Hang will go to the Southwest for a rest until spring.

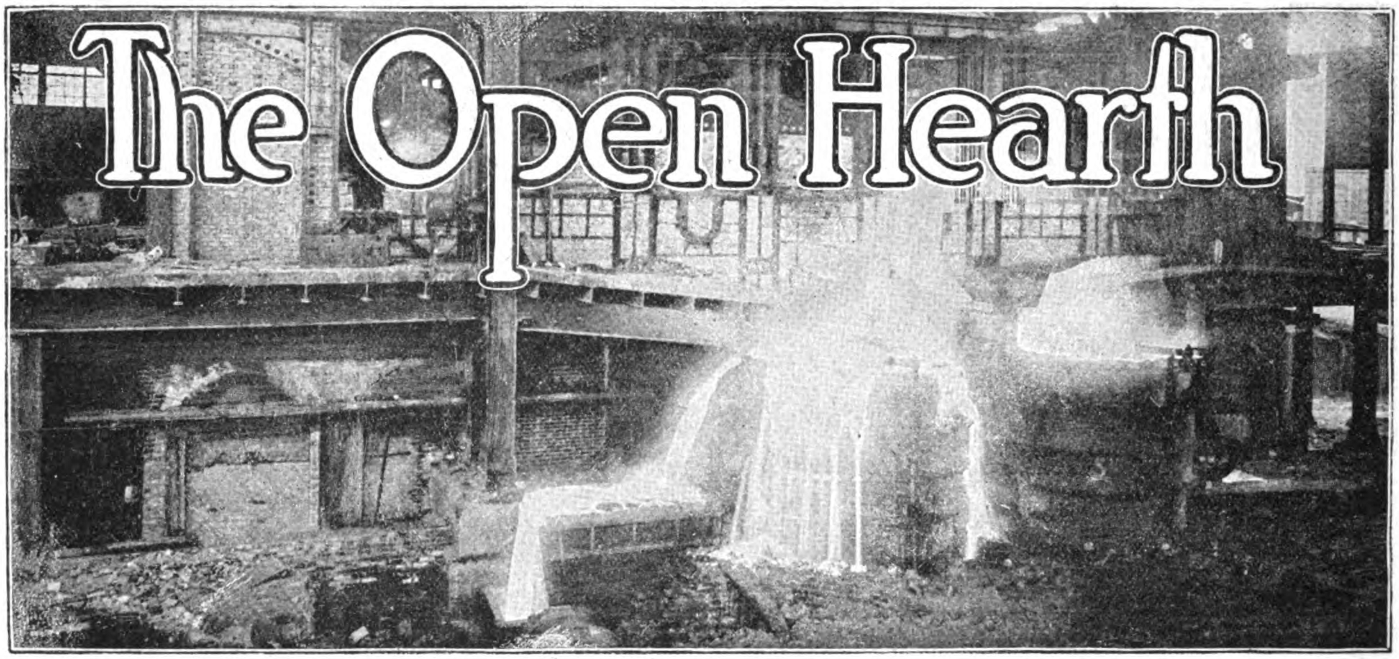
V V

A. Clarke Moore, formerly assistant to the president of Globe Seamless Tube Company, was recently appointed vice-president of the Chicago Railway Equipment Company, Chicago, succeeding the late C. Haines Williams, deceased. Mr. Moore will have general supervision of the manufacturing and selling departments.

V V

A. L. Humphrey of Pittsburgh, president of the Westinghouse Air Brake Company, Wilmerding, Pa., and a director of the Chamber of Commerce of Pittsburgh, has been selected as one of 14 regional directors under the National Unemployment Conference's emergency relief program.

The Open Hearth



George K. Vail, general manager of Arthur G. McKee & Company, engineers, Cleveland, has been elected president of the Ohio Steel Foundry Company, Lima, Ohio, and will leave the McKee firm to become affiliated with the Lima company November 15. Previous to joining McKee & Company, Mr. Vail was associated for some time with the Westinghouse Electric & Mfg. Company, first as a salesman in its Cleveland office and later as district sales manager.

V V

A. D. Chisolm is in Brazil inspecting properties for the Steel & Tube Company of America, Chicago.

V V

G. Herbert Jones, vice president and one of the founders of the Inland Steel Company, Chicago, who, for the past 28 years, has been in active service in charge of sales, has asked to be relieved of his duties in order to rest and devote his time to other interests. Formal action has not been taken and his resignation has not been made formally. However, he is anxious to make the change and it may become effective with the end of this year. Mr. Jones has been an aggressive director of sales for Inland Steel Company in the years of its great growth from a small beginning and feels he has earned a rest. He is developing a fluorspar mine near Rosiview, Ill., the Hillside mine, which is being equipped with modern machinery and every device for the economical production of this material. Mr. Jones desires to devote more time to this interest. In his retirement as vice president he will retain his interest in the company and probably will continue as a director and member of the executive committee.

V V

J. J. Wilson has taken charge of the foundry division of Hiram Walker & Sons Metal Products, Ltd., Walkerville, Ont., a new company which will make a general line of motor castings. Mr. Wilson was formerly connected with the General Motors Corporation in charge of all its foundries.

V V

Col. Henry P. Bope has been elected president of the International Steel Tube Company, Cleveland. Col. Bope was recently director of this Company and R. A. Harmon has been made chairman of the board of directors. Col. Bope formerly was first vice president and general manager of sales of the Carnegie Steel Co., Pittsburgh.

Ralph D. Mock, vice president and former comptroller of the Hydraulic Steel Company, Cleveland, has been made vice president associated with sales; Harry W. Kranz, former superintendent of the Cleveland Welding & Mfg. Company, a subsidiary of the Hydraulic Steel Company, has been made manager of the welding plant and Charles S. Holden, formerly in the sales department of the Cleveland Welding & Mfg. Company, has been made sales manager of the welding plant.

V V

Percival S. Andrews was recently promoted from head bookkeeper to assistant superintendent of the Spencer, Mass., works of the Wickwire Spencer Steel Corporation, Worcester, Mass., and Buffalo.

V V

John V. W. Reynders has been elected chairman of the iron and steel committee of the American Institute of Mining and Metallurgical Engineers, succeeding the late Prof. Joseph W. Richards of Lehigh University.

V V

Walter C. Carroll, assistant general manager of Sales of the American Sheet & Tin Plate Company, Pittsburgh, for the past 13 years, has resigned his connection in this capacity to become vice president and general manager of sheet sales of the Inland Steel Company, Chicago. Mr. Carroll takes with him to his new position a very complete knowledge of the steel business, particularly of steel sheets, acquired over the 13 years he has been affiliated with the American Sheet & Tin Plate Company.

V V

Francis Samuelson, who, it was announced at the Paris Steel Institute, will succeed Dr. J. E. Stead as president of the organization, is to be formally elected at the May, 1922 meeting. Like Dr. Stead, the present president, Mr. Samuelson comes from Middlesbrough. He is the second son of the late Right Hon. Sir Bernard Samuelson, Bart, P. C. F. R. S., eighth president of the Iron and Steel Institute. Sir Bernard was one of the founders of the Cleveland iron trade and sat for many years in the house of commons, being regarded as a special authority on technical education. The president-elect who was born in 1861, succeeded his father in the chairmanship of Sir B. Samuelson & Co., Ltd., ironmasters.

Some Pointers on By-Product Coke Oven Operations

COKE PLANT CHANGES OWNERSHIP

The American Rolling Mill Company and the Whitaker-Glessner Company have jointly acquired all the capital stock of the Portsmouth Solvay Coke Company and have reorganized the company. The name has been changed to the Portsmouth By-Product Coke Company. The main office will be at Portsmouth Ohio, where the by-product coke ovens are located.

The officers of the reorganized company are: President, J. H. Frantz, Columbus, Ohio; vice president, R. H. Sweetser, Columbus, Ohio; secretary-treasurer, H. K. Moore, Portsmouth, Ohio; auditor, J. L. Watkins, Portsmouth, Ohio; superintendent of coke ovens L. D. Huestis, Portsmouth, Ohio.

The Portsmouth By-Product Coke Company owns and operates Freeburn mine in Pike County, Kentucky. Mr. Thomas DeVenny is superintendent of the coal mine. Freeburn mine furnishes high-grade by-product coal to the coke ovens at Portsmouth and also furnishes steam coal to the trade.

TRANSPORTING ORE ON THE MISSISSIPPI.

Towing of iron ore and coal on the Upper Mississippi is assured for next year. The fleet of steel tow boats constructed under authorization of the Shipping Board Emergency Fleet Corporation for up river transportation passed down the Upper Mississippi the last of October from Stillwater, Minnesota, where they have been under construction since the spring of 1920. They are all done but the finishing touches and these will be put on at St. Louis. With the opening of navigation next spring the new craft will tow barges of 2,500 tons capacity each in strings of three, transporting coal north from St. Louis to St. Paul and Iron ore from the Mesaba Range district of Minnesota south.

The boats have been christened the Minnesota, Missouri, Iowa and Illinois, and have been leased together with the big nineteen steel barges to the Mississippi Valley Iron Company of St. Louis. Field Goitra, son of Edward Goitra, president of the Mississippi Valley Iron Company, was aboard the boats on their maiden trip downstream. Many notables were passengers, among them some of the leading engineers of the country. One was William S. Mitchell, the naval architect who designed the craft and supervised their construction.

The four boats, unlike any other seen on the Upper Mississippi made an imposing sight as they passed downstream together. As they cost approximately $360,000 each, the whole tow was undoubtedly the most valuable that has ever been on the upper reaches of the Father of Waters. The contract was the largest single one ever let for inland water craft and was completed conjointly by the three firms, Minneapolis Steel and Machinery Company, St. Louis Boat and Engineering company and the Marietta Manufacturing Company, Point Pleasant, Virginia.

The boats have been specially designed for navigation of the Upper Mississippi. They are 265 feet long over all with a 58-foot beam and draw a maximum of four feet. While designed for burning coal a change of pipe fittings will convert them into oil burners. The wheels are stern type and much larger than the wheels of craft now on the Upper River, having dimensions of 40 x 22. There is a spud directly in front of the pilot house 30 feet long. When the boat is in difficulty, this can be dropped to bottom and act as an anchor. The engines are of the compound condensing type and of 1,800 horsepower. As boats are not designed for passenger and freight traffic comparatively small space is given to cabins. About 25 officers and men will constitute the crew. There are eleven double state rooms besides quarters for the men. The boats have refrigeration plants, electric lights and clarifying and softening water systems. On second deck forward is the captain's office with complete office equipment. The room commands front view of river. An inter-communicating telephone system gives immediate connection with all parts of the ship.

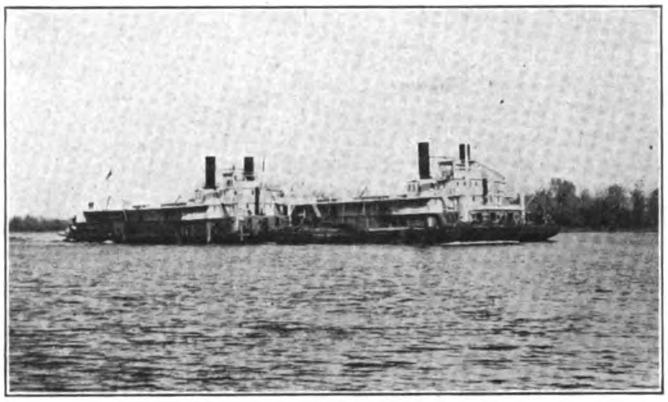


Fig. 1.

The pilot house is a model of its kind. The Steering engine operated by either air or steam with tiller lines rigged to wheel, make it accident proof. Searchlights are operated from the pilot house. Each boat carries a gasoline launch so that it will not be necessary to land for mail and minor supplies. Five ton derricks are used as davits. All decks and superstructure of the boats are of steel.

NEW BOOK ON COVE-OVEN INDUSTRY

T. Biddulph-Smith is the author of "Coke-Oven and By-Product Works Chemistry," recently published by Charles Griffin & Co., Ltd.

For many years crude tar and sulphate of ammonia were the only subsidiaries of the by-product coking industry. The present position of the industry represents a great advance on these conditions, and the modern coke-oven chemist must be alive to the possibilities of an ever-extending field of operation. The realization of the value of benzol and, more recently, of alcohol from coke-oven gas as motor spirit, of coke-oven gas as an important factor in modern lighting problems, and of toluene in the high explosives industry, is in keeping with this extension; and, more over, the chemical efficiency of a coke-oven plant is a factor of which the value is more fully realized year by year. In view of these facts and of the undoubted scarcity of text-books dealing with this specific subject the work is opportune.

The book is a useful work of reference for the more advanced chemist; a study of its contents will give the average student a valuable insight into the chemistry of a modern coke-plant and, more especially, into that of the by-products.

TRADE NOTES

F. J. Ryan & Company, Wesley Building, Philadelphia, specialists in industrial heating problems announce the closing of furnace contracts as follows:

Electric Manganese Steel Company,
U. S. Cast Iron Pipe & Foundry Co.,
Crucible Steel Castings Company:
These are operated under the Mircs Oil Burning Systems.

Armstrong Cork Company,
Penna. Prison Bureau,
George W. Tyrell Company:
These are operated under the Mircs Electric Heating Systems.

The Powdered Coal Development Corporation has been organized with headquarters at Omaha, Nebraska. This company controls the Pruden patents for the burning of pulverized coal in the western half of the United States.

The Universal Crane Company of Elyria, Ohio, announce the appointment of Mr. George L. Sawyer, formerly sales manager of material handling machinery for Barber-Greene Company, as their representative in the New York field. His offices will be at 141 Center Street, New York City.

The Conveyors Corporation of America, Chicago, have issued a new folder describing their American Air Tight Door, a cast iron door of exceptional design and build. Air tight, its use is desirable for ash pits, boiler settings, coke ovens, core ovens, bake ovens, oil stills, dryers, retorts and kilns.

H. V. Schiefer has been placed in charge of the Philadelphia office of The Webster Mfg. Company of Chicago. He has had wide experience in equipment for handling materials, having been affiliated with the C. O. Bartlett & Snow Co., Cleveland, as Chief Draftsman; Messe & Gottfried Co., San Francisco, as Chief Engineer; The Grasselli Chemical Company, Cleveland, as Labor Saving Engineer; and the Arthur G. McKee Co., Cleveland, as Manager of Sintering Plant department. He has contributed freely to the technical press on the subjects of material handling and the sintering of blast furnace flue dust.

W. A. Jones Foundry & Machine Co., manufacturers of power transmitting machinery, announce the appointment of Mr. Fred E. Holtz as their Milwaukee district representative. He will assume his new duties immediately, making headquarters in the First National Bank Building.

Detroit Seamless Steel Tube Company, of Detroit, Mich., announce the appointment of Mr. C. H. Hobbs as asst. general manager of sales. Mr. Hobbs has been with the Lackawanna Steel Co. for over fourteen years.

TRADE PUBLICATIONS

The Stromberg Electric Co., Chicago, Ill., have just issued Bulletin No. 55 describing their "Process Timing and Signalling Instruments." These instruments have been developed to meet the demand for accurate and thoroughly dependable means of automatically operating a signal at the end of a predetermined time, to announce the completion of a process or operation, and has a very broad field of application.

Pawling & Harnischfeger Company, Milwaukee, Wis., have issued Bulletin 56X describing P. & H. Excavating Equipment. This booklet summarizes the achievements of this equipment in road building, irrigation and reclamation, trench and general excavation and in all phases of engineering activity in which earth handling is the prime factor.

W. S. Rockwell & Company, New York, N. Y., in Bulletin No. 239 just issued show an improved type of forge furnace to meet the demand for equipment which will lower production cost. The novel features of the furnace consists of means for better application for heat, protection of the operator, and utilization of waste gases to preheat air and fuel for combustion.

Bulletin No. 206, dated October, 1921, is a new publication illustrating and describing P. & H. Radial Wall Drills made by Pawling & Harnischfeger Co. of Milwaukee. Examples of interior and exterior drilling of large steel drums, and the drilling and reaming of structural material are shown as well as dimension drawings and data. Page 8 is crowded with a list of users of P. & H. Horizontal Drilling and Boring Machines, among them being Allis Chalmers, Bethlehem Steel Co., Lackawanna Bridge Co., General Electric Co., U. S. Navy Yard, Bullard Machine Tool Co., Los Angeles Shipbuilding and Dry Dock Co., etc. etc.

The Pawling & Harnischfeger Company have issued a new bulletin on the P. and H. No. 6 Radial Wall Drill. This drill is designed to meet the demand for a simple and effective machine for drilling, reaming and counter-sinking large unwieldy pieces, such as structural shapes, boiler plates, long beams and similar bulky objects.

Whiting Corporation have issued a new crane catalogue No. 158 to supersede No. 151. The catalogue describes and illustrates this company's standard crane designs.

"Nordberg and the Mining Industry," is the title of a new 9 in. x 12 in., 16 pages and cover booklet issued by the Nordberg Manufacturing Company.

The booklet illustrates the plants of 15 mining companies, gives data concerning their production of copper, gold and silver, mentions the capitalization, assets and dividends of each plant and briefly describes the important equipment, including the Nordberg apparatus, in use.

The Westinghouse Electric & Manufacturing Company has issued leaflet 1732, which describes and illustrates enclosed float switches. These float switches are used on motor operation pumps, to automatically maintain a water level in open tank, reservoir or sump system and to prevent the water from rising above a predetermined level.

Electric Motor Drive for Power Pumps is the title of leaflet 1950 which is being distributed by the Westinghouse Electric & Manufacturing Company. This leaflet gives a discussion of the advantages of the use of electricity for this work, and it specifically points out the type of motor which should be used.

Atlas, Ideal and Victor Reducing Valves, Pump Governors, Pressure Regulators, Hot Water Tank Regulators, Control Valves and Damper Regulators are described in Junior Catalogue No. 21 just published by the Atlas Valve Company, 282 South Street, Newark, N. J. This little catalogue of 20 pages gives complete information — illustrates, describes, lists all sizes and gives prices. A copy will be sent free on request to any reader of this publication.

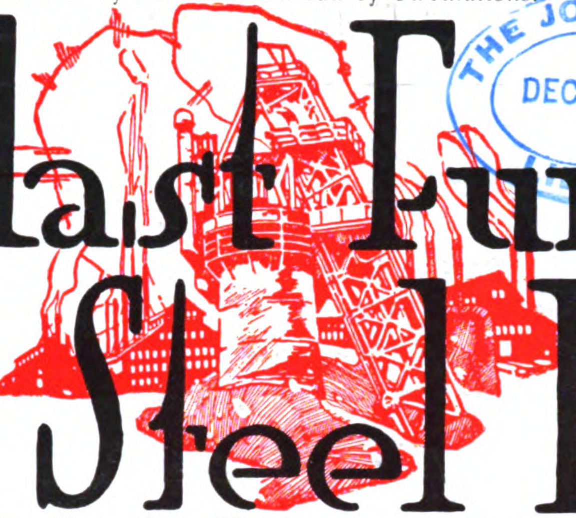
Bulletin No. 234. "The Continuous Heat Treatment of Metals with Automatic and Semi-Automatic Furnaces" is the fourth of the series dealing with fundamentals that influence the quality and cost of heated products issued by W. S. Rockwell Co., 50 Church St., New York.

The Vacuum Oil Company has just issued two educational publications prepared by their Technical Department. The first of these entitled "Stationary Steam Engines" with the sub-title "Steam Valve and Cylinder Lubrication" will be especially interesting to readers of "Combustion" as shown by the following outline: Part I—Reciprocating Steam Engines: Introduction; Classification; Factors of Steam Engine Operation; Mechanical Principles; Lubrication; Selection of Cylinder Oil; Selection of Bearing Oil. Part II—Boiler Plant and Steam Production; Boiler Plant; Steam Quality; Exhaust Steam; Oil in Exhaust Steam; Extraction of Oil; Feed Water Treatment. The second is entitled "Oil Engines, Surface Ignition Type" and considers the Classification, Principle, Operation, and Lubrication of this type of engines. Copies will be furnished upon request.

Member of the Audit Bureau of Circulations.

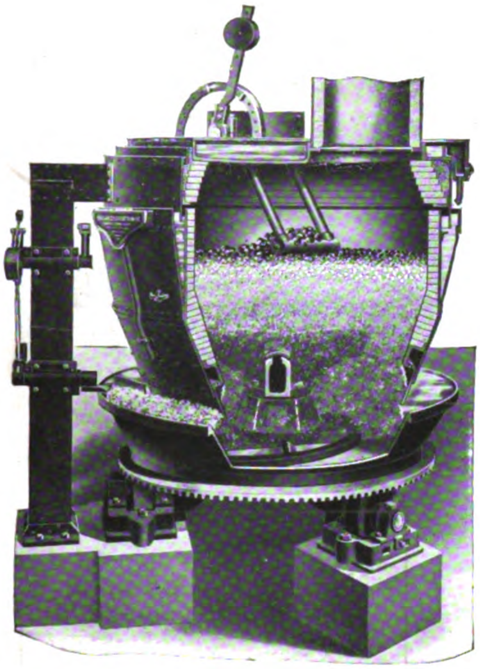
THE JOHN CR
DEC 7 1921

Entered as second class mail matter at Pittsburgh, Pa., under the Act of Congress, March 3, 1879.



The Blast Furnace and Steel Plant

Pittsburgh, December, 1921.



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